

THE  
*PHILOSOPHY* OF *CHEMISTRY*;  
OR THE  
FUNDAMENTAL TRUTHS  
OF  
MODERN CHEMISTRY;  
IN  
A NEW ORDER OF ARRANGEMENT.

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TRANSLATED FROM *c*  
THE FRENCH OF A. F. FOURCROY;

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By R. HERON.

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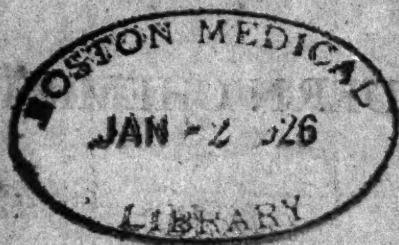
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## ADVERTISEMENT

BY

THE TRANSLATOR.

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The PHILOSOPHY of CHEMISTRY, is a sort of SYLLABUS of the CHEMICAL LECTURES of the Author. It exhibits a compendious and beautiful, systematic view of the whole Science of Chemistry. There is no other Chemical Work of the same character, in the hands of the Public. It deserves to be read, particularly by every person who aspires to the knowledge of general Science. Had it been somewhat more popular and less technical in its composition; it might have served to introduce Chemistry to the acquaintance even of the uninstructed, the indolent, and the gay.

It was judged to be proper, to prefix a Translation of this compendium, as an Introduction to *Fourcroy's Elements of Chemistry*, which I have newly translated: And,

I have likewise ventured to recommend to the Booksellers, to publish a very small separate Edition of my Translation of a Treatise so excellent and so comprehensive.

R. HERON.



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## ADVERTISEMENT.

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**T**HE general truths in any science are continually multiplied, as its perfection advances, and as its means of investigation are improved. Such has been the fortune of chemistry. Its first principles have been but lately ascertained: And it is already rich in corollaries, or general results, which embrace and combine all its parts. A systematic view of these results may be highly useful. During these last twelve years, I have constantly endeavoured to arrange them into some such form. I have often, in my courses of lectures, given a sketch of the arrangement I had adopted: More particularly, in those lectures, with which I every year close my course. When explaining the phenomena exhibited by the known elastic fluids in their evolution, their fixation, and their influence upon all the operations of Art and Nature; I take occasion to review the fundamental principles of the Science; and give such an abstract of its whole materials, as recalls to memory all the changes to which natural bodies are liable, under the power of their reciprocal attractions. But, in any attempt to combine together these capital truths, great perspicacity of discernment is requisite, to enable us to select those more general facts, in which all the minuter ones are so comprehended, that they may be deduced from them, as so many corollaries. Those more general facts must likewise be expressed with perspicuity and precision, without ambiguity, without doubt, without looseness of language. They must not be too numerous, but yet sufficiently so to include every general fact of any importance. They must also be arranged in such a consecutive series, and with a mu-

tual connexion so natural ; that they may exhibit all the elements of the science, and may shew their reciprocal relations and dependencies.

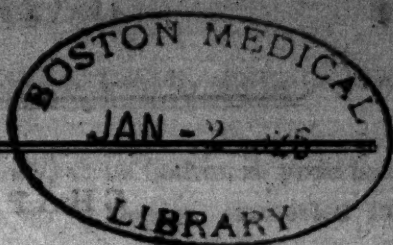
These ideas have regulated my investigation of those truths. I thought that they might serve for the foundations of a complete system of chemistry ; which should embrace such a number of principles, and those so happily applicable to every minuter phenomenon ; that it might enable persons already well acquainted with the science, to recollect all that immense multitude of facts of which it is composed ; and might, at the same time, explain to the beginner in chemical studies, the nature of the course on which he is entering.

It appeared to me, that I should best accomplish this purpose, by exhibiting a regular series of propositions, allied to one another by general relations, and so arranged, that their mutual connexion might be easily perceived. This I call *The PHILOSOPHY OF CHEMISTRY*. All the propositions contained in it, have been already printed under the article AXIOMS, in the chemical department of the New Encyclopædia. For the use of the student of chemistry, I have thought proper to publish them also apart, and in a commodious form.

The success of the first edition of *The PHILOSOPHY OF CHEMISTRY*, has encouraged me to reprint it. I have made a few alterations, and some small corrections, but hardly any addition. The nature of the work is such, that it can be little enlarged, until the science shall be greatly augmented, and enriched with important new discoveries.

PHILOSOPHY





## PHILOSOPHY OF CHEMISTRY.

**A**LL the observations and experiments of Chemistry, may be reduced under the twelve following general heads.

- I. The action of *Light*.
- II. The action of *Caloric*.
- III. The action of *air in Combustion*.
- IV. The nature and action of *Water*.
- V. The nature and action of *Earths*; the formation of *Alkalis*; and the parts which these bodies act in combinations.
- VI. The nature and properties of *Combustible Bodies*.
- VII. The formation and decomposition of *Acids*.
- VIII. The union of *Acids* with *Earths* and *Alkalis*.
- IX. The oxidation and solution of *Metals*.
- X. The nature and formation of *Vegetable Substances*.
- XI. The transition of *Vegetables* into the state of *Animal Matters*; and the nature of *Animal Matters*.
- XIII. Lastly, the spontaneous decomposition of *Vegetable and Animal Substances*.

THESE twelve articles may be made the titles of so many chapters; under each of which, may be introduced all such particulars as have a more natural and direct connexion with it, than with any of the others; and which shall all together comprehend the whole sum of our Chemical Knowledge.



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## CHAPTER I.

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### *The ACTION of LIGHT.*

I. **L**IGHT, whether it be emitted from the Sun and the Fixed Stars, or be naturally diffused through all material space, has four different modes of action in respect to the other bodies with which it comes into contact. It is either reflected wholly without decomposition from their surfaces, so as to give the sensation of *Whiteness*, when it meets the eye: Or it is decomposed, and but partially reflected, exhibiting any of all the variety of colours, except *White* and *Black*: Or it is more or less entirely absorbed, so as to afford to the eye, nothing but a *Black* shade: Or it passes through the bodies meeting it, with a greater or a smaller deviation from its former direction towards the perpendicular; which constitutes *Transparency*.

II. Passing through transparent bodies, it is refracted in the direct ratio of their density, if they be incombustible; and the refraction increases in the direct ratio of the increase of the combustibility of the body through which the light passes. Hence did Newton conjecture the combustibility of the diamond, and the existence of a combustible principle in water.

III. Light suffering refraction, is decomposed into seven different rays; red, orange, yellow, green, blue, indigo, and violet. It has been supposed, that three of these colours are simple; red, yellow, and blue; but the other four, compounded, each of those two which appear on each side, next to it in the refracted pencil of rays; orange, of red and yellow; green, of yellow and blue; indigo, of blue and violet; violet, of red and indigo. This opinion, however, has not been satis-

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factorily proved. The decomposition of light by the prism, is a sort of analysis of it.

IV. Light acts likewise *chemically* upon bodies, in processes of combination and decomposition. Bodies immersed in light, differ in their character, from bodies kept remote from its contact; even when the other circumstances are equal. The former usually become coloured, volatile, and inflammable; the latter exhibit properties opposite to these.

V. By this chemical action of light, some acids are decomposed, and various other salts undergo a change of nature; metallic oxides are in general reduced nearly to the metallic state; vegetables acquire colour, sapidity, and inflammability. Plants withdrawn from the impulse of light, remain white and insipid; in consequence of which they are said to be *etiolated*.

VI. Light seems to produce these effects, almost solely by abstracting from bodies which have been burnt, that principle which they absorbed during the combustion; and by thus restoring to them that combustibility which they had lost. It may be said, that light *unburns* burnt bodies.

The foregoing propositions may be applied to explain

- The colours of bodies;
- Transparency;
- Opacity;
- Brilliancy;
- Single or double refraction;
- Metallic lustre;
- The decomposition of acids and of metallic oxides;
- Decomposition;
- The alteration of mineral colours;
- Vegetation;
- The renovation of the vital air in the atmosphere;
- The decomposition of water by the leaves of plants;
- The formation of oils;
- The differences of nature, which distinguish the vegetables of hot, from those of cold climates.



## CHAP. II.

### *The ACTION of CALORIC.*

I. THAT which mankind in general call *Heat*, is a *sensation* produced by a substance which modern chemists denominate *Caloric*. Caloric applied to the human body, in a proportion larger than that in which it already exists in it, warms our frame, and presents heat to our senses. When matters lower in temperature than our body, are applied to it, there is a portion of its caloric abstracted; and we feel, of consequence, the sensation of cold.

II. Caloric penetrates through all the other substances in nature. It separates their component particles from one another, and makes room for itself among them. It diminishes their mutual attraction; and dilates the bodies which they compose. It fuses solids; and rarefies liquids to such degree that they become invifible, assume the form of air, and are thus converted into elastic, compressible, aeriform fluids. Liquids are therefore combinations of solids with caloric; gasses are solutions of diverse bodies in caloric. Caloric is of itself, the most divided, the most attenuated, the lightest, and the most elastic of all the substances in Nature: And hence, its gravity cannot be estimated.

III. Caloric augments the mutual attractions of contiguous bodies, precisely in the same proportion in which it divides, and



and diminishes the mutual attraction of the component particles of each of them. In consequence of this, it is successfully employed to effect new combinations ; and to promote the reciprocal union of different bodies. Hence the axiom *corpora non agunt, nisi soluta ; bodies act not on one another, unless previously dissolved.*

IV. Every different body, having a form and an arrangement of its constituent particles peculiar to itself, requires a peculiar quantity of caloric, to heat it to any given temperature : which is called its particular *capacity for containing caloric*. From this it follows, that different bodies, even when of the same temperature, and when indicating the same degree of the thermometer, really contain different quantities of caloric,

V. That particular quantity of caloric, which each different body requires, to communicate to it any given temperature, is called its *specific caloric*. And as the differences of this specific caloric in different bodies, cannot be measured by the thermometer ; there has been an *invention* produced, which measures the differences of specific caloric in different bodies of the same temperature, by ascertaining the quantity of ice, which each of these bodies melts, while falling from the same higher to the same lower degree of the thermometer. The differences of the quantities of melted ice, indicate the diversities of specific caloric in the different bodies thus compared. The instrument which this invention employs, is called a *Calorimeter*.

VI. All the experiments of those modern philosophers who have investigated the theory of caloric, concur to prove, that bodies, when they change their state, suffer also a change of their respective capacities for containing caloric. *By the change of the state of bodies*, is meant, the alteration of their solidity, liquidity, or elastic fluidity. By the mixture, therefore, of any two solid bodies, of unequal temperatures, and not entering into mutual combination, but having the same

capacity for containing caloric, we shall obtain a mass of an exactly intermediate temperature. But if these two bodies be of unequal capacities for containing caloric, then the temperature of the mixture will not be precisely intermediate between the temperatures of the two different bodies: And according as it recedes more or less from the precise intermedium, will the difference between the capacities of the two bodies be greater or less.

VII. The foregoing facts shew, that caloric has different attractions or degrees of affinity for different bodies. In all combinations, therefore, the varied attraction of caloric ought to be carefully observed, and estimated.

VIII. When bodies enter into mutual union, they either suffer a loss of caloric; which shews the new compound to have a smaller capacity than its constituent parts had, for containing caloric; and in which case, the process exhibits heat to our organs, and the temperature of the mixture rises; as is the most common effect: Or else the bodies entering into combination, absorb caloric; and the new compound contains more caloric, than its component parts contained when they were separate; in which case, the mixed substances cool, while the combination is taking place; the caloric which was before diffused in a free state among their component particles, is now more intimately combined with them; and there is even an absorption of caloric from contiguous bodies.

IX. Caloric sometimes adheres so tenaciously to particular bodies, as to hinder these from entering into combination with other bodies presented to them. There are various substances, which, when rarefied to the state of gaseous or elastic fluidity, neither unite with extraneous matters, nor with one another. Double affinities must be employed, if we wish to make them enter into new combinations, without having first changed their gaseous form.



X. So powerful is the attraction of caloric for certain bodies, that it is very often usefully employed to detach those bodies from compounds in which they are combined; and to analyse or decompose a variety of compound substances. In distillation, and in processes of decomposition, effected by the aid of fire, the whole process consists in the application of fire or caloric to matters of an extremely compound nature. These matters are thus gradually dissolved; and their principles are severally detached in a vaporous or gaseous form, and in the order of their solubility by caloric.

XI. It often happens, that light applied in conjunction with caloric, aids its operation, and *vice versa*. Chemists find it advantageous to use transparent vessels, which, when in the furnace, admit both light and caloric together. The effect is the same, when opaque vessels are sufficiently penetrated with caloric, to become red-hot, or permeable by light.

XII. Some bodies absorb caloric much more rapidly than others: And this property of absorbing caloric is termed rather *the conducting of caloric*. Those bodies which are the most highly coloured, are in general the best conductors of caloric. But the cause of this phenomenon is unknown.

XIII. All these facts agree in proving, that caloric is a peculiar substance; not, as some philosophers have supposed, a modification of all natural bodies. We know not, as yet, whether it be same with light. The farther we advance in the philosophical knowledge of Nature, the more differences do we still continue to discover between the action of the one of these bodies, and that of the other.

*Application of the foregoing Axioms.*

The Dilatation of solids; and the Rarefaction of fluids;  
Thermometers;  
Fusion;  
Sublimation, and Volatilization;

The



The Calorimeter ; a table of the specific caloric in different bodies ;

The changes of temperature in different mixtures ;

Artificial refrigeration ;

The production, and the fixation of Gasses ;

Distillation, with different temperatures ;

Incandescence ;

The different conductors of Caloric ;

The attractions of Caloric.

CHAP.

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### CHAP. III.

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#### *The ACTION of AIR.*

I. THE air acts in a mass, upon all the other bodies in Nature, by its weight, its dryness or moisture, its temperature, &c. Hence, processes of combination or decomposition to which air has free access, differ greatly from those performed *in vacuo*. And for this reason, it is always necessary, in chemical experiments, to pay careful attention to the indications of the barometer, the thermometer, and the hygrometer.

II. The atmosphere is a vast laboratory in which Nature continually performs numberless processes of analysis, solution, precipitation, and combination. It is an immense recipient, in which all the attenuated and volatilized products of terrestrial bodies, are received, agitated, mingled, combined, or separated. The air of the atmosphere may thus be regarded as a vague and confused mixture of mineral vapours, of minute particles of bodies animal and vegetable, of seminal grains and eggs; through which the luminous, the caloric, and the electric fluids, incessantly pass and repass in all directions. Those great changes to which it is liable; the operation of each of which, extends at once through a wide tract of space, and which are exhibited to our senses, in the  
production



production of water, light, free caloric, and noise ; have received the name of *Meteors*.

III. Although of a composition so extremely mixed, and seemingly uncertain ; yet is the air of the atmosphere, to our perceptions, the same in its primary qualities, whatever the place from which the specimen is taken. Its particular character is distinguished by its two most eminent properties—of *maintaining combustion*, and *being fit for the salutary respiration* of animals. These two grand phenomena are so nearly allied to each other, that a distinct knowledge of the nature of air, may be obtained by the careful observation of what passes in the case of combustion.

IV. A combustible body will not burn, unless it be in contact with atmospheric air, or with a certain substance extracted from atmospheric air. Combustion cannot take place *in vacuo*.

V. In any given quantity of air, a combustible body can burn only for a certain proportionate space of time. An hundred parts of atmospheric air, contain only twenty-seven parts that can contribute to combustion. After a combustible body shall have absorbed these twenty-seven parts, the combustion will then stop ; because the remaining seventy-three parts can be of no use to promote it. Atmospheric air is a compound of two different substances ; having only some other extraneous matters mingled with it ; which do not exceed an hundredth part of the whole. Of those two component principles of atmospheric air, *one* serves for the purposes of combustion and respiration, and is called *Vital Air* ; the *other*, differing from vital air, in possessing qualities directly contrary to its two most eminent ones, is called *Gas Azote*.

VI. A body burning in common air, therefore, actually analyses this fluid ; detaches the vital air ; and by absorbing it, gains an increase of weight, and undergoes a change of nature. The gas azote that remains, is lighter than atmospheric air ; extinguishes combustion, and destroys animal life ;

life; and is, as we shall hereafter see, a principle in the composition of many bodies, particularly of ammoniac or the volatile alkali, of the acid of nitre, and of animal substances.

VII. A combustible body, after being burnt in atmospheric air, and absorbing as much vital air, as it is capable of receiving into combination with it; cannot again burn, although it be immersed in fresh air; but has become incombustible, and generally saline.

VIII. A body burning in atmospheric air, never entirely absorbs the 27 parts of vital air. To detach the whole of the vital air, from any quantity of the air of the atmosphere, and thus to accomplish a complete analysis of the latter; combustible bodies must be repeatedly immersed in it, and the combustion renewed for several different times in succession.

IX. That portion of air which is thus absorbed by combustible bodies, and which we have hitherto named *Vital Air*, is likewise denominated *Gas Oxigene*. It has received the *first* of these names, because it is the only elastic fluid fit for the salutary respiration of animals. The *second* has been affixed to it, because many bodies are, by the absorption of it, rendered acid.

X. Combustion consists, then, in the fixation and absorption of vital air by combustible bodies, and in the decomposition of atmospheric air by these bodies. Since no elastic fluid but vital air, can act the same part in combustion; it is easy to conceive, that a body which is sufficiently combustible to absorb all the vital air out of a given quantity of atmospheric air; may be employed as a means of ascertaining the precise proportions in which the two elastic fluids of the atmosphere are combined together in it. Phosphorus is, upon this principle, at present used as an *Eudiometer*, to indicate the purity of air, that is, to shew what proportion of vital air it contains.



XI. As vital air is a *Gas*, and many combustible bodies, by absorbing, fix it, and make it take a solid form ; it must necessarily happen, that vital air, when thus precipitated, will lose the caloric to which it owed its elastic fluidity. Hence comes that free caloric or heat, which is evolved during combustion.

XII. Combustible bodies differ from one another, 1. In the degrees of rapidity, with which they respectively absorb oxigene ; 2. In the quantities of oxigene which they respectively absorb ; 3. In the proportions of the caloric which they severally disengage from the oxigene absorbed ; 4. And consequently, in the more or less perfect solidity of the oxigene contained in them all, after combustion.

XIII. Burnt bodies may therefore be defined to be *bodies combined with oxigene*. They are called also, *oxigenated* or *oxidated substances*. And since the greater part of those bodies which are known to us, are either *burnt* or *combustible* ; there is reason for thinking, that a number of incombustible natural bodies, the composition of which is unknown, may possibly be hereafter found to be incombustible, only because they are already saturated with oxigene. In several instances, this conjecture has been already confirmed by the progress of chemical discovery.

XIV. From several of these preceding axioms, it follows, that when we burn a combustible body, that it may give us heat ; as, in our domestic apartments, in the cold of winter ; we derive, not from the combustible body, but from the air itself, the greater part at least, of the caloric which exists in combination with it. [It may even be asserted, that the colder the air, so much the more heat does its decomposition afford ; for the colder the air is, the more is it condensed ; and so much the greater is its quantity in proportion to its bulk. We know, that the heat of our common fires becomes much more lively and intense, when the surrounding air is suddenly cooled. The art, too, of increasing combustion by

x

pouring

pouring a stream of fresh air, with bellows, upon wood already inflamed, is founded upon this principle \*.]

XV. Combustion, therefore, decomposes not only atmospheric air, by the absorption of one of its principles; but also the vital air abstracted, by absorbing, fixing, and solidifying more or less, the *oxigene* or base of the vital air, in the combustible body; and by disengaging in greater or smaller abundance, the *caloric* which was the solvent of that base.

XVI. Combustion exhibits another interesting phenomenon which has been explained by modern chemistry. This is

\* The Author seems here to misrepresent, or to express obscurely, the true chemical fact. *Cool air* is cold and dense, only for want of *caloric*, to rarefy and warm it. Before the *caloric* can escape, and the *oxigene* enter into combination with the *burning body*; the *vital air* must ever be saturated with *caloric*, to that point at which the *attractions* of *oxigene* for the *combustible body*, and of *caloric* for other contiguous substances, are sufficient to overcome the mutual attraction by which *caloric* and *oxigene* are held in union, in *vital air*. Now, one combustible body may indeed have a more powerful attraction for *oxigene* than another; *oxigene* may have absorbed *caloric* beyond the due point of saturation. And hence will the quantity of *caloric* vary, which is necessary to fit *vital air* for ordinary *combustion*. But this variation is never such as the author seems in the text to suppose. Cold air is always rarefied by the absorption of a new quantity of the surrounding free *caloric*, before it enters into combustion. A stream of dense, cold air, revives and inflames combustion,—solely by the more rapid *mechanical* expulsion of the freed *gas azote*; by the absorption or expulsion of the evolved *caloric*, which would otherwise have floated about, so as to make the process languish; and by a removal of the ashes, or the new compound of the combustible body and *oxigene*, in consequence of which, fresh parts of the combustible body, are exposed to the contact of the vital air. The action of *bellows* in promoting inflammation, is thus almost wholly mechanical.—In reading those sentences of the text which I have inclosed within brackets, it is to be carefully remembered, that, *cold air does not necessarily contain more caloric, than the same bulk of hot air may contain*; but only has a *capacity of containing more*; which must commonly be more or less satisfied, before it can be decomposed by combustion. H.



is the disengagement of light, or the production of flame. It is certain, that the greater part of the light which constitutes flame, is contained in vital air, of which it is a component principle: 1. Because combustible bodies yield much more flame, when they burn in vital air alone, than in atmospheric air: 2. Because some combustible bodies afford no flame, unless when burning in pure vital air: 3. Because, in order to abstract oxigene out of bodies containing it, for the formation of vital air; it is necessary not only to dissolve the oxigene in a greater or smaller quantity of caloric, but also to add, at the same time, a due portion of light: 4. Lastly, Because there are burnt bodies, which, at the bare contact of light, are deprived of their oxigene. The last of these four facts is expressed by the terms, *unburning* and *decombustion*; phænomena which were said, in the first chapter, to be produced by the action of light.

XVII. Vital air is therefore a compound of *oxigene*; a solidifiable, ponderous, acidifying base; held in solution by *caloric*, and *light*; which are of themselves substances in a state of extreme attenuation, extremely elastic, and having no measurable gravity. Combustion consists in the more or less perfect precipitation of oxigene from its union with these its two solvents.

XVIII. A combustible body, then, when burning, disengages from vital air, not only caloric, but light also. Every different combustible body disengages its own peculiar portion, as well of light as of caloric, from vital air. There are probably some combustible bodies which disengage more of caloric than of light from vital air; and others again which disengage from it more of light than of caloric.

XIX. Oxigene that is fixed in burnt combustible bodies, is therefore more or less entirely deprived of its light and caloric. The density, the solidity, which it then acquires, is one of the causes that regulate the more or less easy separation of oxigene from burnt, combustible bodies, for the formation of

new

new vital air. Some of these bodies require, in order to this, more of light than of caloric, while others take more of caloric than of light.

XX. From what is here said, it is easy to conceive, that the abstraction of oxigene from a burnt body, is a process directly the reverse of combustion. Our language wants a word to express this operation. It may be said to *unburn* or *de-oxidate* bodies: And hence we may derive *unburning* or *de-oxidation*, as names to denote the event accomplished.

XXI. Oxigene, beside adhering more or less tenaciously to combustible bodies, according as it is in its union with them, more or less solid, and has lost more or less of its solvents, caloric and light; is also attached to those bodies by virtue of its attractions, or peculiar affinities for every different one of them respectively. We are already acquainted with many of these affinities of oxigene, for different bodies: And of some of them, the precise forces even, have been correctly ascertained.

XXII. By means of these affinities, we often make oxigene to pass from a burnt, into a combustible body. A species of combustion then takes place, which is more or less tacit and secret, in proportion as the oxigene is more or less solid in its combination with the burnt body, and more or less in the same state of density, as the substance into which it is passing. But this species of combustion is sometimes accompanied with vivid flame and heat; phenomena which are exhibited, whenever the body which receives the oxigene, requires it in a state more solid than that in which it existed in the substance now divested of it. Thus iron, zinc, antimony, arsenic, &c. burn with flame, when heated in contact with oxide of mercury: They rob this oxide of its oxigene, and require the oxigene to become more solid, as it enters into combination with them.



*The foregoing propositions may be applied to explain*

The resistance which the air makes to evaporation, to the ebullition of liquids, to sublimation, &c.;

The solution of water in air, and the variations of the dryness and moisture of the atmosphere ;

The efflorescence and deliquescence of saline bodies ;

Aqueous meteors ;

Experiments made at different heights in the atmosphere ;

Experiments made *in vacuo* ;

The comparative natures of combustible bodies ;

The increase of the weight, and the change of the nature of these bodies after combustion ;

The history of native burnt bodies ;

Artificial flame and heat ;

The theory of furnaces ;

The different processes performed with *Eudiometers*, for ascertaining the degree of the purity of air ;

The respiration of animals ;

The reduction of air to a mephitic by the effects of combustion and respiration ;

The support, diminution, and augmentation of animal heat ;

Transpiration from the skin and from the lungs, &c.

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## CHAP. IV.

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### *The NATURE and ACTION of WATER.*

I. WATER exists in three different states. It is *solid* in ice; it is best known as a *liquid*; it is expanded by rarefaction into *vapour* or *gas*.

II. Ice is a crystallization more or less regular, transparent, highly sapid, elastic; fusible at a temperature above  $32^{\circ}$  Fahrenheit; and which when entering into several new combinations, still gives out caloric, notwithstanding its previous apparent destitution of heat.

III. Ice of the temperature of  $32^{\circ}$  of Fahrenheit's thermometer, requires to its fusion, precisely that quantity of caloric which would be sufficient to raise an equal quantity of water to the temperature of  $167^{\circ}$  Fahrenheit. Its capacity for containing caloric, is therefore not precisely the same as that of liquid water: a difference owing to the peculiarity of the state of ice; as has been explained in the VI. Section of the II. Chapter.

IV. Whenever liquid water loses much of its heat, in entering into a new combination; it may be considered as becoming solid. In such combinations, it is often more solid than



ice at the temperature of  $32^{\circ}$  F. Hence the solidity of mortar, and other cements made with flaked lime.

V. Water remains eternally solid, on various mountains which have been for ages chilled by the presence of ice, as well as under the poles. It there forms a sort of rocks, or hard and white concretions, not unlike to stones.

VI. Liquid water is pure and tasteless, without smell, and 850 times as heavy as an equal bulk of air. It forms rivers, lakes, ponds, springs, brooks, &c. It occupies cavities, furrows, and in general all the lowest parts of the surface of the globe.

VII. It is rarely pure. At the surface, and in the interior parts of the earth, it dissolves and retains air, saline gasses, and terrene salts. It even acts upon the most solid stones, wears them down by attrition, deposits the particles which it carries with it, and forms them into crystallized figures. It has been, on this account, named the great solvent of nature. It gives rise to many phenomena; and is one of the prime agents which are for ever modifying anew the surface of the globe. Its motions, its currents, its action, have at length changed the nature of minerals, and have created, as it were, a sort of new world, upon the old.

VIII. All waters on the earth contain, therefore, some extraneous substances. The presence of these may be recognized by the extraordinary specific gravity of the water; by its taste being more or less insipid, earthy, and crude; by its aversion to boil, and its inability to soften pulse, or to froth soap. That water is the most pure, which is the farthest from possessing these qualities.

IX. Water, running over a bed of quartzose sand, and in contact with air, is sufficiently pure for the ordinary purposes of life, and of the arts. But, water which passes through chalk, plaster, or marble, or which stagnates over *peat-earth*, bitumen, mineral ores, or in subterraneous caverns, at a distance

distance from the action of the atmosphere; is always more or less impure.

X. Chemistry corrects the impurity, crudeness, and hardness of waters, by exposing them to the air, agitating them in contact with it, by boiling, distilling, and then *aerating* them. The addition of alhes, alkalis, and light acids, serves to remove in part, the bad qualities of water, and sometimes even destroys those qualities altogether. Most of those extraneous bodies by which the purity of water is altered, being either much more volatile, or much more fixed in their nature than water; distillation is therefore the surest means for purifying water. Chemists, for this reason, use always distilled water in their experiments.

XI. As liquid water is a combination of ice of the temperature  $32^{\circ}$  F. with such a portion of caloric as would be sufficient to raise a quantity of water equal to the quantity of ice employed, to the temperature of  $167^{\circ}$  F.; therefore caloric added to liquid water, rarefies it. At  $212^{\circ}$  F. water takes a gaseous form, and is diffused in vapour. This vapour is much lighter, and in proportion to its actual weight, is expanded into a much greater bulk, than liquid water. It easily penetrates through all other bodies, and is dissolved in air. The elastic efforts which it makes to expand itself, whenever it experiences an increase of temperature, fit it for moving the largest bodies.

XII. As liquid water absorbs air, and thus becomes lighter; so air also absorbs and dissolves water. Hence the evaporation of water. This solution of water in air is dry and invisible, like the air; it follows the ratio of the temperature of the atmosphere. The hygrometer does not accurately indicate the presence of water in this state; for a perfect solution of water in air, does not at all affect that instrument. But water about to be dissolved in air, and still more water precipitated from this solution, never fail to alter the indications of the hygrometer.



XIII. Water is not, as it was long supposed to be, a simple body. Upon the rapid combustion of various combustible bodies, more or less intensely heated; such as charcoal and pitcoal both previously kindled, iron red-hot, zinc in fusion and red-hot, oils, &c.; water presented to these bodies in this state, undergoes a decomposition; and a quantity of oxygen derived from it, is fixed in the combustible bodies.

XIV. While the *oxygen* from water is *fixed* in those combustible bodies which it kindles and inflames; the other component principle of the water, being susceptible of solution in caloric, forms *inflammable gas*, which is diffused in an uncombined state. This second substance, as being one of the elementary principles of water, has been named *hydrogene*; and its elastic fluid solution in caloric and light, has been called *gas hydrogene*. That disengagement of this substance into gas, which takes place whenever water is decomposed by a combustible body, is the cause of a great number of detonations and fulminations.

XV. The gas hydrogen obtained in very many chemical processes, comes always from water; *either* radically, and by the effect of a former decomposition, by which the hydrogen has been abstracted from water, and fixed in some other body which now resigns it; *or* by the immediate and instantaneous decomposition of water itself.

XVI. It has been ascertained by many experiments, that water contains about 0,85 of oxygen, and 0,15 of hydrogen. The composition of water by a chemical process; one of the noblest discoveries of modern chemistry; confirms the certainty of the analysis of water. For, 0,85 parts of oxygen, added to 0,15 of hydrogen, give 1,00 parts of pure water.

XVII. The decomposition of water by a combustible body, is always effected by the double affinities—of the oxygen of the water for the combustible body, and of caloric for the hydrogen of the water. On this account, the greater the quantity

tity of the caloric matter employed ; so much the more rapid is always the decomposition of water by iron, charcoal, &c. From this need of a great abundance of caloric, in this process, an idea may be drawn, of the manner in which hydrogen, one of the component principles of water, comes to acquire a degree of levity so much greater than that of the water in which it before existed : A cubic foot of water weighing 70 lib.; while a cubic foot of gas hydrogen, weighs only 61 grains.

XVIII. Gas hydrogen, which is always *originally* derived from the decomposition of water ; carries with it, usually a considerable portion of the body with which it was last combined ; and this either in suspension or solution, according as that body was of a nature more or less mixed. It is commonly mixed with gas azote, with carbonic acid gas, or with vital air ; or it holds in solution, water, carbone, sulphur, phosphorus, arsenic, oils, alcohol, æther, &c. According as its purity is contaminated by one or another of these different substances ; it varies in odour, gravity, inflammability, the colour of its flame, its action upon different substances, and the extraneous products which, beside pure water, it affords, when burnt. Hence all the different species and names of inflammable gas, the generic base of which, is always gas hydrogen.

XIX. Gas hydrogen being one of those natural substances which contain the most caloric ; is one of those combustible bodies which the most easily suffer their caloric to escape ; and which, by consequence, afford the most heat, when burning. Hence, all compound, inflammable matters ; such as oil, grease, and in general all those which are obtained from organized bodies ; having hydrogen for one of the most abundant principles in their composition ; yield much heat, during their combustion. Of this character, are also timber, oils, pit-coal, bitumen, alcohol, æther, &c.



XX. It follows also from the preceding facts, that compound, combustible bodies, containing much hydrogen in their composition; must require, when they burn, a very large proportion of oxygen, and will afford water, as a product of their combustion, in just proportion to the quantity of hydrogen which they contain. Thus a pound of alcohol gives by combustion, more than a pound of water, &c.

XXI. The combustible bodies that decompose water, are in general, those which have a stronger attraction for oxygen, than hydrogen has. But the efficacy of this attraction is greatly aided by the presence of caloric, which for its part, tends to combine with hydrogen. Great abundance of caloric, may even render water decomposable by bodies, which, if cold, would be unable to decompose it. Light also contributes to the same effect.

XXII. Combustible bodies which, at whatever temperature, do not decompose water, on account of the faintness of their attraction for oxygen; which is in this case always weaker than the attraction between oxygen and hydrogen;—will, on the contrary, after being burnt by other means, undergo decomposition by suffering hydrogen to abstract the oxygen which they had acquired, when burning. This happens to the oxides of lead, bismuth, &c.

XXIII. Chemistry knows, as yet, no other means of decomposing water, but by presenting to it, combustible substances capable of detaching and absorbing its oxygen. We are acquainted with no bodies that we can apply in art, to absorb the hydrogen, and leave the oxygen disengaged. Nature, however, possesses instruments by which she can accomplish this particular decomposition of water. The leaves of vegetables, when the rays of the sun fall upon them, seem to decompose water, to absorb its hydrogen, and to evolve its oxygen into vital air. This appears to be, in part, the mechanism

nism of vegetation, of the formation of oils, and of the renovation of the atmosphere. See Chap. IX.

XXIV. While hydrogene and oxigene, dissolved each into into gas by the efficiency of caloric and light; remain both cold; they cannot combine, although brought into mutual contact: no inflammation is produced by their mutual impulse; there is no water formed. But when a burning body is presented to the mixture, when it is powerfully compressed, or if it receive any sudden and violent shock: the two gasses then begin to unite; combustion ensues; and water is produced.

XXV. It should seem, that a like event happens in the atmosphere. Detonations in the air, or claps of thunder, are probably nothing else but the combustion of hydrogenous gas with vital air; and are accordingly followed, for the most part, by heavy showers of rain. Other tempestuous rains appear also to be owing to the sudden formation of water in the atmosphere; in consequence of the rapid combustion of hydrogenous gas and vital air; occasioned by the electric spark, and by the necessity for restoring the electric equilibrium between one cloud and another, or between the clouds and the earth.

XXVI. A multitude of chemical phenomena in nature and art, that seemed formerly to be unaccountable and miraculous; are now perceived to be necessary consequences of the decomposition of water. The influence of the general facts enumerated in this chapter, is very great, upon the whole theory of chemistry. They will recur to our notice in all the subsequent chapters.

*Application of the preceding propositions.*

Artificial refrigeration;

Theory of icy mountains, and of the polar ices;

Varieties of the waters of the earth and atmosphere;

Art of correcting the bad qualities of water;

Theory



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*Application of the preceding propositions.*

Artificial refrigeration;

Theory of icy mountains, and of the polar ices;

Varieties of the waters of the earth and atmosphere;

Art of correcting the bad qualities of water;

Theory



Theory of the ebullition of water ;  
Difference between boiled and aerated water ;  
Distillation of water in large quantities ;—of salt water ;  
Theory of mists and dews ;  
Theory of the hygrometer ; and of the phænomena measured by it ;  
Inflammation of combustible bodies by water ;  
Gasses disengaged from the waters of marshes ;  
The diversity of inflammable gasses ;  
Colouring by inflammable gasses ;  
The oxidation of metals, or rust formed by moist air ;  
Theory of detonation ;  
Some of the phænomena of the solution of metals ;  
Some fundamental principles towards a theory of vegetation, of the formation of oils, &c.

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## CHAP. V.

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### *The Nature and Action of EARTHS and ALKALIS.*

I. WHAT was formerly meant exclusively by the name of *Earth*; and was supposed to be an *elementary* substance, the cause of solidity, dryness, insipidity, insolubility, &c.; is no longer to be regarded in any other light, than as one of those vague, indeterminate ideas, which the imagination dissatisfied with the fruitlessness of experiments, often frames to amuse it, instead of facts. We now acknowledge no such thing as *elementary* earth. Instead of one, we have attained to the knowledge of five terrene substances; each of which has an equal right to be termed *elementary*, since each of them is found to enter into very many compounds.

II. Of the five simple terrene substances which have been discovered, there are two in some sort more eminently earthy than the rest, more dry, more susceptible of hardness, more insipid, &c. The other three possess saline qualities which give them a similitude of nature, to alkaline substances. These last three have been therefore denominated *Salino-terrene*, *saline earths*, *alkaline earths*, *terrene alkalis*. The two first are *silices* and *aluminos*. The latter three are *barytes*, *magnesia*, and *lime*.

III.



III. Each of these five earths, is distinguished by *specific* characters, beside those *generic* qualities which belong to all the five, in common. Their generic characters are, dryness, unalterability by fire, the property of not being liable to decomposition, and of acting, in combinations, as simple, indestructible substances.

IV. *Silices*, has been named also *siliceous earth*, *quartzose earth*, *vitriifiable earth*. It is rough to the feeling of the hand: it scratches and wears down metals; it is infusible, and incombustible; insoluble in water or acids—at least the greater number of acids; it is soluble by alkalis, when exposed in contact with them, to an intense heat, and in consequence of this solution, forms with them a glass. This simple earth is found in great abundance, in sand, quartz, flint, agate, jasper, grit, and in all scintillating stones, which, indeed, have it for their bases. It has not, as yet, been either decomposed, or imitated by synthesis. It has been considered as the simplest of all earths, the element of earth, the principle of every other sort of earth: but these opinions have not hitherto been justified by observation or experiment. It is applied to a multiplicity of uses, for mill-stones, the manufacture of glass, cements, pottery, &c.

V. *Alumines*, so named, because it forms the basis of alum, is called also *Argill*, by some writers. It is soft to the finger, adheres to the tongue, forms a paste with water, hardens in the fire. It combines with most acids, dries into flakes, and assumes extraordinary hardness when mixed with water and *silices* together. It is contained in a large proportion, in common clays, in pipe-earth, in schistus, steatites, &c. In many of the arts it is employed, as a substance adapted to receive and retain any artificial form, which may be baked by the fire, and which is fit to resist the penetration of water. Its intimate nature or component principles are unknown; it has been erroneously regarded, as *silices* altered, divided, and mouldered down by the action of air and water.

VI. Barytes, or *ponderous earth*, is a substance remarkable for its extraordinary gravity. In nature, it is never found alone, but always in combination with the sulphuric or the carbonic acid. It takes a green or blue colour, when exposed to the action of fire, in contact with the filices, or aluminés of the crucible. In nine hundred parts of water, it dissolves; it communicates a green colour to the syrup of violets; it has a greater affinity than even the alkalis with most of the acids; its origin is unknown; but it is suspected to be a metallic oxide; it serves, at all times, to detect the presence, and ascertain the quantity of the sulphuric acid.

VII. Magnesia is a substance very fine and white; not subject to alteration by fire; soft and light; it resembles the feculum of vegetables, and requires nearly two thousand parts of water to dissolve it. It communicates but a faint greenness to the tincture of violets and mallows; with acids, it forms salts which are very soluble, and in which the magnesia is combined with a force of attraction so much less than that with which lime adheres to acids, that they are all liable to be decomposed by lime. The attraction of magnesia for the acids, is nearly the same as that of ammoniac; accordingly ammoniac and magnesia entering together into combination with acids, thus form a class of triple-salts, or salts with two bases. This earth exists in a sufficiently perceptible proportion, in serpentines, mica, slate, amianthus. Like the preceding earths, it is indecomposable, and of unknown composition.

VIII. Lime, the most alkaline of all the earths, is the only one that has an acrid taste, hot, almost caustic, disagreeable, and urinous. It gives a dark-green tinge to syrup of violets, and when slaked in the open air, attracts moisture from the atmosphere. Under the action of water, it becomes exceedingly hot, and absorbing the water, becomes solid, in combination with it. When slaked barely by exposure to the atmosphere,



mosphere, it gives out caloric, largely : it is soluble in less than seven hundred times its own weight of water. Dissolved, it attracts carbonic acid from the atmosphere ; and on the surface of the solution, forms a pellicle of chalk which has been improperly termed *Cream of Lime*. Alone, it is unalterable by fire ; but with silices and aluminas, is reducible to fusion. It is plainly a compound ; but its component principles are unknown.

IX. That earths are occasionally converted into one another, is merely a vain dream of naturalists. We have no proofs, that silices is by long exposure to the air, changed into aluminas ; that flints are transformed into chalk ; that chalk is converted into magnesia ; as has been too hastily inferred from some slight and casual appearances.

X. The three alkaline earths have more the appearance of being compound, than magnesia or lime. We have reason to believe, that azote is one of their component principles ; and that they owe to it their alkaline properties. Yet this opinion has not hitherto, been sufficiently confirmed by experiments. The formation of the alkalis, is, indeed, with great probability, ascribed to marine animals ; and the fact that these contain much azote, seems to suggest, that azote is the grand alkaligenous principle in Nature.

XI. It has been supposed, that the five earths are of a metallic nature ; and it has been pretended, that by violent ignition with charcoal, their reduction into the metallic state, has been effected. But those very few, and very small metallic globules which have been in such instances obtained, came evidently from the charcoal, and from the earth of the cupels : and those having been discovered to be phosphure of iron, whatever the earth in the treatment of which they were procured ; it is hence evinced, that the earths afford no metallic matters. Some philosophers indeed continue to regard the earths, as a species of burnt bodies, in which oxygen is extraordinarily adhesive ; and which, on account of this adhesion,

hesion, cannot be decomposed. But, this opinion is, as yet, unconfirmed by observation or experiment.

XII. Earths combine with one another; two and two, three and three, and even in compositions more complex; by processes unknown to us, but which Nature continually accomplishes in the great way; by them, producing stones various in hardness, structure, transparency, opacity, colour, form, &c. Art cannot imitate these compounds, for want of time, of sufficient masses of the materials, and of an adequate extent of space. Yet it produces something similar to the natural compounds of the earths, by preserving long in mutual contact, mixtures of the earths, which have been well wrought together, and at the first, moistened with a little water.

XIII. The three alkaline earths hold an intermediate place between the earths and the alkalis; and are allied alike to both. The alkalis are known by their acrid, burning, urinous taste, their causticity, their peculiar action on the skin and all other animal matters, their converting the blue colour of violets to a green or even a greenish yellow, and their deliquescency. The known species of alkali, are three, potash, soda, and ammoniac. Of these, the two former are named *fixed alkalis*; because they melt and become red in the fire, before being volatilized: the third, as being in this respect, of an opposite nature, is termed *volatile alkali*.

XIV. Potash is known by the following characteristics. It is dry, solid, white, crystallized in rhomboidal plates, fusible at the temperature of  $235^{\circ}$ , extremely deliquescent; it absorbs water with the evolution of heat, and a peculiar, faint odour; by fusion, it combines very well, and forms a transparent compound with filices. In nature, it is often found with lime, and in combination with different acids. It is obtained more especially from vegetables; in the ashes of which it remains, after their combustion. It has been thought to have such a resemblance to lime, that it might possibly be formed by the combination



combination of that substance with azote. But this opinion is unconfirmed by experiment.

XV. Soda is obtained by the incineration of marine plants, and forms also the basis of common sea-salt. It has a remarkable resemblance to potash in its form, causticity, fusibility, deliquescency, its fusion with silices, its action upon animal matters, &c. It long was, and still might be confounded with potash. But the neutral salts which potash forms in combination with acids, are entirely different from those which soda forms with the same acids. Soda has been supposed to be a compound of magnesia with azote; because salts with a base of magnesia, are as often found together with salts which have soda for their base, as calcareous salts, with such as have for their base, potash. But neither the one idea nor the other, is well founded.

XVI. Ammoniac or *volatile alkali*, differs greatly from the two preceding species. Its form is gaseous and peculiar, when it is dissolved in caloric; dissolved in water, it has a liquid form equally peculiar; its odour is lively and suffocating; it is soluble in the air; it is known to be easily decomposable by the electric spark, by metallic oxides, and by the nitric, or the oxygenated muriatic acid. This decomposition has shewn ammoniac to be a compound of hydrogen with azote; and in consequence of this circumstance, it often exhibits the phenomena of a combustible substance. This also explains the reason why animal matters under putrefaction, give out ammoniac.

XVII. Should azote hereafter be ascertained to be the principle to which alkalis owe their formation; the atmosphere will then appear to be a compound of *oxigene* and *alkaligene* each dissolved, separately, in caloric. It will appear to be a vast reservoir, out of which the philosopher may behold nature drawing the materials of the two classes of compound agents which are the most active, and the most useful, in very many of her operations.

*Application of the Propositions in this Chapter.*

The extraction, the preparation, and the purification of earths.

The theory of the arts of making earthen-ware, bricks, tiles, pottery, porcelain ;

The theory of cements and mortars ;

The reciprocal combinations of earths by fire ;

The natural history of earths and stones ;

The compound nature of earths and stones ;

The natural alterations of stones ;

The changes of colours by the alkalis ;

Vitrification, and the processes of the glass-maker ;

The extraction and purification of potash and soda ;

The theory of alkaline caustics ;

Some particulars relative to putrefaction.

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## CHAP. VI.

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### *The Nature of COMBUSTIBLE BODIES.*

I. COMBUSTIBLE bodies are too numerous, various, and important in the phænomena which they present, and the combinations with one another and with air, into which they continually enter; not to deserve to be examined with the utmost care, in order to the discovery of their different properties and specific characters.

II. Comprehending under this denomination, all substances that are capable of entering, more or less rapidly into union with oxigene, and of disengaging from vital air, its light and caloric: We must next distinguish those substances into two classes; simple or undecompounded, combustible bodies; and those combustible matters which are, in their nature, more or less compound.

III. We call those combustible substances, simple, which chemistry has not hitherto been able either to decompose, or to form synthetically. Their intimate nature is unknown. They are found sometimes solitary, in the mineral kingdom, or in the two other kingdoms of nature; but almost always combined two and two together. Of this character are diamond, hydrogen, sulphur, phosphorus, carbone, and all metals.

tals. Each of these six genera, is worthy of being examined by itself.

IV. *Diamond* is the hardest of all bodies. It is very remarkable for the force with which it refracts and decomposes light; and from which NEWTON inferred, that it was highly combustible. In nature, it exists crystallized in octohædra, duodecahædra, &c. It has some varieties of contexture, density, and colour. It burns with a perceptible flame; and while it burns, is reduced to vapour. Its combination with oxigene is still unknown. Few bodies act upon it; were it not for its combustibility, it might be supposed absolutely unalterable. We know of no compound bodies into which it enters, as a component principle: of all the bodies in nature, it seems to be the least subject to chemical attraction.

V. *Hydrogene* is one of the component principles of water; and in combination with caloric and light, forms gas *hydrogene*. The weight of this gas is to that of atmospheric air, as *one* to *sixteen*. It is insoluble in most other substances; but, on the contrary, dissolves sulphur, phosphorus, carbone, arsenic, oils, &c.; and by these solutions forms various sorts of inflammable gas; which are at present named *sulphurated, phosphorated, carbonated, arseniated, oleaginous, &c. hydrogenous gas*. It decomposes several metallic oxides, and some acids, of which the *radical* principles are simple and well-known. To all its compounds, whether combustible or incombustible, it communicates a considerable refringent power. Because water possessed this power of refraction, NEWTON skilfully conjectured, that it must contain some such combustible substance, as this which has been at last discovered in its composition. Hydrogene is also fixed in organic bodies, and forms a principle of those mixed, combustible matters which they contain. See Chapters IV. and X.

VI. *Sulphur* is a yellowish substance, odorate, electric, transparent, and octohædral, opaque, and prismatic, fusible, and



subject to two different sorts of combustion. Of these combustions, one is slow, with a bluish flame, and yields sulphureous acid; the other is rapid, with a white flame, and produces sulphuric acid. Sulphur enters into combination with earths and alkalis; and by these combinations is rendered soluble. It unites with metals, and forms with them sulphureous ores, which exist in great abundance, in the earth, and either in a solitary state, or in combination with pure metals.

VII. *Phosphorus* is a white substance, transparent, crystallized, lamellated, and very fusible. It is subject to two different sorts of combustion; burning, either slowly, at any known temperature, with a whitish flame, an acrid odour, and the formation of phosphorous gas; or at the temperature of  $167^{\circ}$ , rapidly, with a vivid and very brilliant flame, without any sensible smell, and with the formation of phosphoric acid. On account of its extreme combustibility, it is never found pure, in nature. It enters with sufficient readiness, into combination with sulphur, and metals. It dissolves in gas hydrogen; detaches the oxigene from various metallic oxides; separates the metals from the acids, in the perfection of their metallic form and lustre. It exists in minerals, even more abundantly than in animals, to which it was formerly supposed to be peculiar.

VIII. *Carbone*, the combustible matter of coals, when pure from earth, alkali, salts, &c. may be burnt, if subjected to an intense heat. With oxigene, it forms carbonic acid. Of all known substances, it has the strongest attractions for oxigene; which it detaches from all other burnt bodies. It exists in a large proportion, in both animal and vegetable matters of all sorts. Of vegetables, it is almost the only solid base; and on this account, still remains in their form, after they have been decomposed, either spontaneously, or by the action of caloric. It dissolves in the alkalis, and in gas hydrogen. It unites with metals; forming, particularly,  
with

with iron, carbure of iron; which is found in all the kingdoms of nature, and has been improperly termed *Lead-ore*, *Plumbago*, and *Black-lead*.

IX. The metals are well known by their ponderosity and brilliancy. They are fusible, crystallizable, combustible. They decompose water and various acids, combine with sulphur, phosphorus, carbone, and with one another, at different temperatures. In the state of oxides, they act in respect to the earths and alkalis, the part of acids; and again serve to the acids, as so many salifiable bases. This genus differs from the preceding genera, in possessing many species. In order to give a short account of these species, of which there are now seventeen, well known,—a number which will probably be much enlarged by future investigation; I shall divide this *Genus* into five *Sections*. In the first section I shall comprehend metals brittle and acidifiable; which are three species; arsenic, tungsten, and molybdena. To the second section, I refer metals that are brittle, and oxidable only; being five species; cobalt, bismuth, nickel, manganese, and antimony. The third section will include two species of metals which are semi-ductile and oxidable; zinc and mercury. To the fourth section belong metals which are highly ductile, and easily oxidable; such as tin, lead, iron, and copper. Lastly, To the fifth section remain those metals which are highly ductile, but not easily oxidable; and these are the three species of silver, gold, and platina. As the *ninth chapter* is entirely appropriated to the purpose of explaining the most important chemical properties of metals, it will be sufficient here to mention briefly, some of the specific differences by which these bodies are distinguished from one another. It may be proper to observe, that the names of *semi-metals*, *imperfect metals*, *perfect metals*, having been, evidently, derived from the errors of alchemy, ought to be banished from the language of a science that has now attained to considerable accuracy.



A. *Arsenic* appears in plates of a bluish grey colour, brilliant, brittle, and which burn with a blue flame, and with the exhalation of a smell of garlic.

B. *Tungsten* is of a greyish white colour, granulated, friable, almost infusible, almost insoluble in acids, but very easily oxidable and acidifiable by air and caloric.

C. *Molybdena* presents itself in a powder, or in blackish grains which are brilliant, agglutinated, brittle, scarcely fusible, and which burn into a white oxide, that is volatile, prismatic, and acidifiable.

D. *Cobalt* is granulated, fine, of a rose-white colour, brittle and pulverizable, not easily fusible, and becomes blue, when it is melted with glass.

E. *Bismuth* appears in large plates of a yellowish white colour, brittle, very fusible, very crystallizable, very oxidable.

F. *Nickel* is grey, granulated, hard, not brittle, scarcely fusible, and yields a green oxide, under the action of caloric and air.

G. *Manganese* is of a greyish white colour, fine-grained, brittle, not fusible without great difficulty; the only metal combustible in the open air, and which instantly changes its colour; and is, within a few days reduced to a black powder. To preserve manganese from this spontaneous combustion, it must be kept in alcohol, or oil.

H. *Antimony* is white, pure, with large plates, brittle, difficult to melt; yields by combustion in the open air, a white oxide, which is sublimated and crystallized; and which combines with the alkalis in the same manner as an acid.

I. *Zinc* is of a bluish white colour, in large plates, semi-brittle, not without some degree of malleability, easily fusible, the most inflammable of all metals; when red-hot, it burns with a beautiful, yellowish white flame; it decomposes water with great energy.

K. *Mercury* is fusible at the temperature of  $35\frac{1}{2}^{\circ}$  below zero in Fahrenheit's thermometer; and at  $38^{\circ}$  under zero, congeals. It may be reduced to a black oxide (*æthiops persæ*) by mere division; and this simple process extinguishes and fixes it in all those thick or viscid matters with which it is usually triturated.

L. *Tin* is a glittering white substance, soft, light, scarcely sonorous, susceptible of being scratched by the nail, very fusible, very combustible; which yields a white oxide that impairs the transparency of glass, and converts it into enamel.

M. *Lead* is bluish, dusky, soft, heavy, easily fusible. It yields an oxide, more vitrifiable than the oxide of any other metal, and a glass of a topaz-yellow colour.

N. *Iron* is white, fibrous, the most tenacious of all metals, very averse from fusion, very combustible, the only metal attractable by the magnet. It acts with great efficacy in decomposing water; is reduced to a powder, by exposure to the open air; combines with charcoal, which converts it into steel; and is the only metal that abounds in the two organic kingdoms of nature.

O. *Copper* is of a beautiful, glittering red colour. It is very soft, very ductile, odorate, poisonous. It burns with a green flame: its oxides are brown, blue, and green. The green oxide requires humid air to its formation.

P. *Silver* is white, pure, and brilliant, without smell and without taste, highly ductile, not oxidable by caloric and air. It burns with a greenish flame, when acted upon by the electric spark. The vapours of sulphur, blacken it. By the action of air alone, it is unalterable.

Q. *Gold* is of a beautiful, glittering yellow colour, highly ductile, less combustible and oxidable than silver, less alterable than silver by the contact of air. The electric spark reduces it to an oxide of a beautiful purple colour.



R. *Platina* is the heaviest of all metals, of a greyish white colour, with little brilliancy; the most infusible, the least combustible, the least alterable of all metals. It may hereafter become one of the most valuable instruments of the arts.

X. Compound combustible bodies are such as result from the mutual combination of two or more of the foregoing simple combustible substances. The solutions of sulphur, carbone, phosphorus, arsenic, in gas hydrogen; are inflammable compounds. The combinations of sulphur with phosphorus; of carbone with iron; of metals with sulphur, with phosphorus, or with one another; are so many compound combustible bodies. These are the combustible matters, the most common in nature. Art separating them from one another, obtains them pure and solitary.

XI. A comparison of the properties of compound combustible bodies with those of the simple, shews that the former sometimes absorb oxigene more eagerly than their component principles would do if separate; as in the instances of many alloys and metallic sulphures: but that, on the other hand, some compound combustible matters are rendered more averse from burning than their principles disunited would be, by means of that strong energy of attraction which these principles exert one upon another; as is the case with all phosphorated metals in general. Some of these combustible compounds remain long unalterable in the air; seem to have in some manner lost their combustibility, by their mutual combination; and are at last kindled, only by the application of a strong heat to them: Of this character is carbure of iron, which has been usefully employed to preserve iron from rusting.

XII. Hydrogene and carbone are united in the most intimate manner in the capillary tubes of vegetables. They often contain in their combination, small portions of earth, alkalis,

kalis, and acids, but especially of oxigene. They form bitumens, oils, and refin's; which, although tending to combustion, and a separation of their principles; yet remain for some time in the equilibrium of combination; until a sudden rise of temperature, and the contact of air or water, destroy the equilibrium, divide the elements of the compound, and bring them separately into union with oxigene. The products of the combustion of those compounds, are always, water and carbonic acid. The same thing takes place in the case of alcohol and æther, which are formed by modifications of the principles of vegetables, and which, in an ultimate analysis, are found to be merely combinations of hydrogen and carbone, with more or less of oxigene and water. See Chapters X. XI. and XII.

XIII. This short view of the different species of combustible substances, and of their principal characteristic properties, shews what an important part these bodies act in the phenomena of nature. It authorises us to divide almost all natural products into two great classes; *combustible* bodies, and *burnt* bodies. In the magnitude and the action of the former class, we see the cause of inflammable meteors, partial heats, volcanoes, perpetual changes of the surface of the earth, &c. In the existence of the second class, we perceive the source of the varieties and number of the acids, of the compound salts, of oxides and metallic salts, which diversify in a thousand ways the aspect of ores in the earth; the reciprocal decompositions of these substances; and the alterations they undergo from water, air, and light. Vegetables appear to be so many machines organized by nature, in order to accomplish the intimate mutual combination of many of these combustible substances; and thus to produce compounds, the unpermanency of which, makes them peculiarly serviceable to the grand designs of nature.



*Application of the foregoing propositions.*

The history of the combustion of every different combustible body, in particular detail.

The history of sulphurated soils, and of native sulphuric acid.

The phenomena of natural inflammable gasses in quarries, mines, the atmosphere, &c.

The properties of terrene, alkaline, and metallic sulphures.

The conversion of sulphures into sulphates and sulphites, by the action of air and water.

The properties, extraction, and combinations of phosphorus; metallic phosphures.

The existence of metallic carbures in nature.

The phenomena which respect the density, the gravity, the ductility, and the fusibility of metals.

The properties and uses of alloys.

The formation of secondary ores; by transition from native metallic salts.

Volcanoes; sulphureous and bath waters.

Bitumens; the comparison of sulphur, charcoal, and other simple combustible bodies, with oils, &c.

C H A P.

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## CHAP. VII.

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### *The FORMATION and DECOMPOSITION of ACIDS.*

I. ALL acids resemble one another in taste ; in their manner of giving a red colour to vegetable substances ; in their common tendency to combine with earths, alkalis, and metallic oxides ; and in the property of attracting and being highly attractable. It was therefore natural to conclude, as did Sir I. Newton, that they resembled one another also in their intimate essence, and possessed some homogeneous principle common to them all. This truth, chemical analysis, with the assistance of the new inventions in chemistry, has ascertained beyond a doubt.

II. Since every acid contains oxigene, and loses its acidity, in proportion as it is deprived of this principle : Acids are therefore to be regarded as burnt or oxygenated bodies, which resemble one another by containing, all, more or less of the same acidifying element,

III. The nature of acids, may be examined in two ways ; either by producing them from their elements by combustion, uniting oxigene with substances liable to be acidified by it ; or by decomposing, and *unburning* acidified bodies, so as to de-

tach



tach the oxigene, by means of other substances having a stronger affinity with it.

IV. Considered in this last point of view, all known acids may be arranged in three classes; 1. Acids which we can both compose and decompose, and with the nature of which we are fully acquainted: 2. Acids which we can compose, but not decompose, and with the nature of which we are, by consequence, more imperfectly acquainted: 3. Acids which have not been, as yet, either composed or decomposed, and of which the nature is, by consequence, wholly unknown to us.

V. Of nearly thirty species of known acids, there are, strictly speaking, only three, of the intimate nature of which we are entirely ignorant, as having been hitherto unable either to compose or decompose them. We may, therefore, regard the character of acids in general, as being well ascertained; and may proceed to consider them in their general properties, and with respect to their composition.

VI. All acids are, then, compounds of [*oxigene* with *some other body*: The *former* principle, common to them all, being the cause of their general resemblance, and of those qualities in which they all agree; while the *latter*, which is different in every different acid, presents itself as the source of those specific qualities which are peculiar in each. The peculiar materials combined with oxigene in the various acids, are, on this account, called the *radical* or acidifiable principles.

VII. The acids are, then, all combinations, of the *radical* or acidifiable principle peculiar to each species, with oxigene, a principle common to all the species. Hence it follows, that their common properties, which give them the acid character, depend on oxigene; and that their mutually distinguishing qualities, which mark their specific characters, are owing to their radical principles.

VIII. The term *Acid* denoting the essential, general nature of these substances, forms the generic name. The peculiar  
name

name of the radical principle, added to that of the genus, may serve to distinguish each acid in particular. Thus, sulphur is the *radical* of the *sulphuric* acid; phosphorus, of the *phosphoric* acid; carbone of the *carbonic* acid, &c.

IX. Although this nomenclature possesses the advantage of expressing, with precision, the nature of every different acid, yet, it has not, hitherto, been applied to all the acids; because the radicals of some of them, are still unknown; and of others, the radicals are themselves so compound, that their names could not be introduced into those of the acids to which they respectively belong, without producing too great a multiplicity of words.

X. The acidifiable radicals may be combined with more or less oxigene; and in this view, are susceptible of two different states of acidification. In the *one*, they are combined with the smallest portion of oxigene that is not insufficient to render them acid; and in this case, their acidity is very weak, and they act with but little energy on those bases which form with them, neutral salts: In the modern systematic chemical nomenclature, this state of combination and acidity, is denoted by terminating the name of the weak acid in the syllable *ous*: Thus, we say the sulphureous, the nitrous, the phosphorus, the acetous acid, &c. The *second* state of acids, is that in which they contain a larger proportion of oxigene, and are for the most part completely saturated with it: They then possess all the attractive energy of which their acid nature is capable; and this state is expressed in the new nomenclature, by the final syllable *ic*, in contradistinction from *ous*: Thus we say the sulphuric, the nitric, the phosphoric, the acetic acids.

XI. In regard to the proportion of oxigene combined with the acidifiable radicals, what is said in the last section, may even be greatly extended in its signification. Every radical may be considered as capable of existing in four different states: 1. As containing very little oxigene, not even enough



to give it any thing of an acid nature; and in this state, it is but an oxide; such as sulphur coloured red or brown by exposure to the air; which is but an oxide of sulphur: 2. As containing more acid, than in the former case, so much as is sufficient to render the compound a weak acid; and such is the sulphureous acid, &c.: 3. As containing still more oxigene than in the second case, and being now so saturated, as to constitute a powerful acid; such is the sulphuric acid: 4. Lastly, As containing a portion of superfluous oxigene, above what is requisite to render it a strong acid; it is now called an *oxigenated*, or even a *super-oxigenated acid*.

XII. From these foregoing facts, it appears, that there are two ways of forming acids at pleasure, with these several proportions of oxigene. In *one*, we combine the radicals with the quantities of oxigene which are precisely necessary to bring them into the new state that we desire to produce; as is done with sulphur, phosphorus, and arsenic. In the *other*, we detach from those acids which contain the greatest possible quantity of oxigene, certain proportions of the acidifying principle, by means of those combustible bodies with which it most eagerly combines.

XIII. This last method depends on the attractions of oxigene for the different combustible bodies, and is often successfully employed, to effect the entire decomposition of acids, by abstracting all the oxigene contained in them. Acids, by this means, inflame combustible substances. In order to this, it is only necessary, that the acids employed, contain no solid oxigene; and that the inflammable matters brought into contact with them, be able to absorb the oxigene which those acids contain, into a state more solid than that in which it exists in the acids. It is not, however, every one of those acids which are decomposable by combustible bodies, that can heat the combustible matter to inflammation.

XIV. Heated charcoal is employed with sufficient success, to decompose all the acids susceptible of this decomposition.

But there are other combustible bodies which serve the same purpose. Such are most of the metals, phosphorus, sulphur, hydrogen in that dry and solid state in which it exists in its vegetable compounds.

XV. All the acids owing, as has been explained, their specific differences to their respective radical principles; they may be distributed into four classes, the distinctions of which shall be founded upon the *nature* of the radicals, as it is *known* or *unknown*, *simple* or *compound*.

A. The *first* of these classes, contains those acids of which the radicals are known and simple; that is, which are formed of undecomposed combustible substances, united with oxygen. It comprehends the following species; the sulphuric acid, the nitric acid, the carbonic acid, the phosphoric acid, the arsenic acid, the tartaric acid, and the molybdic acid.

B. The *second* class include acids having unknown radicals, but such as are strongly suspected to be simple. The muriatic acid, the fluoric acid, and the boracic acid, are of this character.

C. I rank in the *third* class, acids of which the radicals are known to be of a binary composition. Such are the vegetable acids, whose common radical is composed of hydrogen and carbone. The succinic acid belongs likewise to this class.

D. The *last* class consists of acids, the radicals of which, are composed, each at least of three different substances. Such are the animal acids, which have for their radicals, combinations of carbone, hydrogen, and azote.

XVI. Not only are these several classes of acids, distinguished by general characteristics, marking each class: But even each particular acid has its peculiar properties, by which its character is discriminated from the characters of all other acids. These properties may even be expressed by words and phrases, not less simple and easy than those which Linnæus taught



taught naturalists to employ. A sketch of this mode of expressing these properties, follows below.

XVII. The acids with simple and known radicals, are all decomposable by combustible bodies, which they burn with more or less activity; and are thus reduced to their radicals. By this decomposition was the nature of the radicals first discovered. These acids may be also composed anew, by uniting oxigene with their radicals.

The acids, whose radicals are unknown, but from strong analogies, suspected to be simple; have no other classific character, but that of being indecomposable by combustible bodies, and not to be formed by art.

The vegetable acids, with binary radicals, are characteristically distinguished; 1. By being all decomposable by a strong heat, and by the addition of a due quantity of oxigene: 2. By affording, when they are thus decomposed, water and carbonic acid; which are formed by the preparation of their hydrogen and carbone, and by the union of each of these bodies, separately, with oxigene: 3. By their slow, spontaneous decomposition, when they are dissolved in water, and exposed to a temperature above  $54\frac{1}{2}^{\circ}$  F.: 4. Because they cannot be decomposed by any known combustible body; since their radical is compounded of two substances, which are remarkable, as having the strongest possible attraction for oxigene: 5. Because they are mutually convertible in consequence of differing from one another, at the first, in nothing else but the proportion of their principles.

The more compound acids with three or more radicals, which derive their origin from animal matters; although the least known of all the acids; have also some properties which may be regarded as their classific characters. Such are, the property of yielding ammoniac, when they are decomposed by fire, and of affording Prussic acid by a change in the proportion of their principles.

XVIII. To these classific characters, we shall next add the specific characters ; and shall here endeavour to employ a systematic, technical language, similar to that of the botanist, and the zoologist.

*Acids of the first class, having radicals which are simple and known.*

A. Sulphuric acid ; formed from sulphur and oxigene, by the combustion of the sulphur ; inodorate, twice as heavy as water, very caustic, less volatile than water ; affording sulphureous acid gas and sulphur, by its decomposition with *red-hot coal*, metals, &c. ; forming sulphates with the earths, alkalis, and metallic oxides.

B. Sulphureous acid, highly odorate, very volatile, gaseous ; destructive to blue vegetable colours, and fit to cleanse away spots made with these colours on a white ground ; absorbing, by slow degrees, the oxigene from the air, and from various acids or oxides ; forming sulphites with the earthy and alkaline bases.

C. Nitric acid, liquid, white, caustic, of a strong nauseous smell ; formed of azote and oxigene ; capable of inflaming sulphur, charcoal, zinc, tin, and oils ; liable to lose, by the action of combustible bodies upon it, various proportions of its oxigene, and thus producing nitrous acid, nitrous gas, and nitrous oxide ; destructive to colours ; possessing the power of burning vegetable and animal substances, making them yellow, and converting them into acids ; decomposing that ammoniac which is produced by the putrefaction of animal matters ; forming nitrates with the earths and alkalis ; remaining in an imperfect union with metallic oxides, and having a tendency to acidify them.

D. Nitrous acid, or nitric acid with an inferior proportion of oxigene ; in the form of a gas, red or orange coloured ; extremely volatile, discolouring vegetables, becoming blue and green with water ; communicating a yellow colour to nitric acid, when united with it in various proportions ;

D

yielding



yielding nitrous gas, under the contact of combustible bodies; and forming nitrites with the earths and alkalis.

E. Carbonic acid is formed of carbone in the proportion of 2,28 parts, united with 0,72 of oxigene; is a gas heavier than common air, which it displaces; fills subterraneous cavities; is evolved from liquors in vinous fermentation; extinguishes lamps, kills animals, reddens only light blue vegetable colours; produces a precipitate of chalk in lime-water, but again dissolves the chalk in the water; mineralizes acidulous waters, and enters into combination with barytes, lime, copper, iron, and lead in mines and quarries; forms carbonates with the earths, alkalis, and metallic oxides; is decomposable only by phosphorus, and when it is in union with alkaline bases, particularly with soda, in the state of a carbonate.

F. The phosphoric acid is composed of phosphorus and oxigene, combined by a rapid and entire combustion; is liquid, thick, or solid, vitrifiable by fire; dissolves silices, while in the act of vitrification; is decomposable by carbone, by which it is reduced to simple phosphorus; and forms phosphates with the earths, alkalis, and metallic oxides.

G. Phosphorous acid differs from the phosphoric, only in containing less oxigene; is volatile, and odorate; detaches oxigene from many other bodies; and forms phosphites with terrene, alkaline, and metallic bases.

H. The arsenic acid is formed of the metal called *arsenic*, in union with oxigene. Combustion reduces arsenic only to an oxide; and the nitric, or the oxygenated muriatic acid, is then necessary to afford the additional quantity of oxigene requisite to convert the oxide into acid. The acid thus obtained, is fixed, fusible into a glass, decomposable by the action of a large quantity of light and caloric, and by many combustible bodies; forms arseniates with earth, alkalis, and metallic oxides. The oxide of arsenic which combines also with

the same bases, may be regarded as a sort of *arsenious* acid.

I. Tungstic acid is a compound of the metal of tungsten, with oxygen; exists in the form of a white or yellowish powder, fixed, infusible, scarcely soluble, reducible into tungsten by hydrogen, carbon, &c.; forms the native tungstate of lime, which is called *Lapis ponderosus*, and the native tungstate of iron, or *wolfram* of mineralogists.

K. Molybdic acid is a compound of the metal named *molybdena*, with oxygen; is of a harsh taste; is like the two acids last preceding, metallic; exists in the form of a white powder; becomes blue by the contact of those bodies which reduce it; and then by the loss of its oxygen, passes back into the state of molybdena.

*Acids of the second class, of unknown radicals.*

XIX. The acids of which the radicals are unknown, but suspected to be simple, are three in number; the muriatic acid, the fluoric acid, and the boracic acid.

A. The muriatic acid is a gaseous or fluid substance, of a pungent smell, unalterable by any known combustible body; deprives all combustible bodies, particularly metallic oxides, of their oxygen, and is thus changed into *oxygenated muriatic acid*. Oxygenated muriatic acid is remarkable for its greenish yellow colour; its power of thickening and constricting the organs of animal bodies; its property of destroying the colours of vegetable substances, and of inflaming the most part of combustible bodies; its capacity to form with potash, a salt which rapidly kindles hot inflammable matters, and produces the purest vital air that is known.

B. The fluoric acid is a gaseous substance; forms in the air, a very thick white vapour; corrodes glass; dissolves siliceous earth; and with this earth forms a permanent gas, from which water separates a part of the silices.



C. The boracic acid is dry, crystallized in hexahædral plates, fusible into a glass, almost insipid, scarcely soluble, fusible with silices, very feeble in its affinities, and liable to yield up the terrene and alkaline bases to almost any other acid.

*Acids of the third class, having binary radicals.*

XX. The acids with binary radicals, mixed or compound, belong almost exclusively to the vegetable kingdom, and are formed by the union of carbonated hydrogen, or hydrogenated carbon, with oxygen in various proportions; which, as was before observed, accounts for their reciprocal conversion into one another. These acids are considerably numerous; and their number may probably be augmented by progressive discoveries. I have therefore divided them into five genera, distinguished from one another, by generic differences in their formation. The *first* of these genera includes those pure acids which are formed in vegetables; comprehending the succinic acid, which is evidently of vegetable origin: In this genus, are five species; the succinic acid, the citric acid, the gallic acid, the malic acid, the benzoic acid. The *second* genus contains those vegetable acids, which are fully formed in vegetables, but are at the same time partly saturated with potash; they are called acidula; they are two species; the tartareous acidulum, and the oxalic acidulum. In the *third* genus, I rank all acids which are formed by the action of the nitric acid, and the precipitation of its oxygen, upon vegetable substances: Of this genus, we know as yet only the distinct species of the camphoric acid: The oxalic and malic acids indeed, are not unfrequently formed from vegetable matters, treated with nitric acid. In the *fourth* genus, I place those acids which are formed in vegetables by treatment with fire; such as the pyromucous, the pyro-ligneous, and the pyro-tartareous acids. The *fifth* genus consists of vegetable acids produced by fermentation; of this

this genus we know none but the acetous species. The following are the specific characters of these twelve acids.

A. The succinic acid is disengaged and sublimated from heated amber; is of a strong bituminous smell, oleaginous and inflammable, volatile, crystallizable into needles; forms permanent crystallizable salts, particularly with metallic oxides; and adheres more tenaciously to the three earths, than to the alkalis.

B. The citric acid is crystallizable into rhomboidal plates; is not convertible into oxalic acid by the nitric acid; has a more powerful affinity with the earths, than with the alkalis; is readily decomposed in water, or by fire.

C. The gallic acid exists in abundance in nut-galls; is crystallized into small grey or yellowish needles; is stiptic; produces a black precipitate from solutions of iron; reduces metallic oxides which it finds in union with other acids; is convertible into oxalic acid by the nitric acid.

D. The malic acid abounds in apples; is not crystallizable; is convertible into oxalic acid by the nitric acid; is formed, at the same time as the oxalic acid, or even more quickly, in vegetables treated with nitric acid.

E. The benzoic acid is obtained from benzoin, storax, balsam of Peru, vanilla, and cinnamon, by means of heat; is crystallizable into flattened prisms; has an aromatic smell when heated; is fusible by a gentle heat; is volatile, inflammable, scarcely soluble in water; is soluble, but not decomposable by the nitric acid.

F. The tartareous acidulum, is formed of tartareous acid, imperfectly saturated with potash; exists in wines; is crystallizable, and decomposable by fire; affords a large proportion of carbonic acid and oil, with a plentiful residue of carbonate of potash; by distillation, yields pyro-tartareous acid; is scarcely soluble; is decomposable in water; forms triple salts with the alkalis and metallic oxides; becomes highly soluble upon the addition of borax or boracic acid to it. The



tartareous acid obtained from this acidulum, is crystallizable into needles interwoven together; is unalterable in the air, is highly soluble, affords acidulum, upon receiving the addition of a small portion of potash; decomposes so much of sulphate, nitrate, or muriate of potash, or soda, as may afford potash sufficient to reduce the acid to acidulum; is convertible into oxalic acid by the action of the nitric acid.

G. The oxalic acidulum is formed of oxalic acid partially saturated with potash; is obtained as an extract from salt of sorrel; is crystallized in parallelipeds; is hardly decomposable by fire; detaches lime from any other acid; is precisely similar to the acidulum formed by the nitric acid, when it is brought into contact with any vegetable matter whatsoever; is unalterable by the nitric acid; is the least decomposable, and the most oxygenated of all vegetable acids.

H. The camphoric acid is formed by the action of the nitric acid distilled upon camphor; is crystallizable in parallelipeds; forms with earths and alkalis, neutral salts that are highly crystallizable; does not, like oxalic acid, abstract lime from all the other acids; is very little known.

I. The pyro-tartareous acid is a modification of the tartareous acid, produced by fire; has the smell and colour of a burnt body; is very easily rarefied; and bubbles up very much, under the action of heat; is not crystallizable; forms with earthy and alkaline bases, salts different from those which the tartareous acid yields with the same bases; is but little known.

K. The pyro-mucous acid is formed by the distillation of gums, sugar, and fecula; has a lively agreeable odour of caramels; is volatile; colours vegetable and animal matters with a red hue; is decomposable by intense heat; is but little known.

L. The pyro-ligneous acid is obtained from wood by distillation; has a pungent, foetid smell; is not crystallizable; is decomposable by a strong heat; is volatile; forms peculiar  
salts

salts with earths, alkalis, and metallic oxides ; has peculiar attractions for these bases ; and as to its other qualities and relations, is not better known than the two species last preceding.

M. The acetous acid is formed by the fermentation of wine, and is on this account named *Vinegar* ; has an agreeable taste and smell ; is liquid, volatile, and decomposable by ardent heat ; is liable to be supersaturated with oxigene, when it is distilled with metallic oxides ; and becomes in consequence of this change acetic acid or *radical vinegar* ; which is much more acrid and more odorate than the acetous acid ; and is also inflammable, and mixed with alcohol.

*Acids of the fourth class, with ternary radicals.*

XXI. The acids whose radicals are ternary compounds ; and which have been in general described as consisting of carbone, hydrogen, and azote in union with oxigene ; belong chiefly to the animal kingdom. They are still less known than those of the third class. But, seeing that they all furnish ammoniac by decomposition with fire, and Prussic acid by a change in the proportion of their principles ; I am led to observe, that that the Prussic acid seems to stand in the same relation to this genus of acids, as that of the oxalic acid to the vegetable acids in general. When animal substances are by treatment with nitric acid, converted into oxalic acid, there is constantly formed at the same time, a portion of Prussic acid, which is disengaged in vapours.

There are seven known animal acids, which appear to belong all to this genus of compounds ; namely, the lactic acid, the saccho-lactic acid, the sebatic acid, the lithic acid, the formic acid, the bombic acid, and the Prussic acid. Each has its characteristic properties.

A. The lactic acid is formed by the addition of a small portion of acetous acid to milk spontaneously soured ; is not crystallizable ; is soluble in alcohol ; yields by distillation,



an acid analogous to the pyro-tartareous acid; forms deliquescent salts with the terrene and alkaline bases; decomposes alkaline acetites.

B. The saccho-lactic acid is precipitated in a white powder from the oxalic acid formed by sugar of milk and nitric acid; is almost insipid, and almost insoluble; is decomposable by fire, and yields by this decomposition, a sublimated salt, having the odour of benzoin, and which forms crystallizable salts with the alkalis; is very little known.

C. The sebacic acid is obtained from greafe by the action of fire; is separated likewise from greafe by the alkalis and lime, with the help of a strong heat; is liquid, white, fuming, very acrid in odour and taste; forms crystallizable and fixed salts with earth and alkalis; decomposes muriate of mercury; is decomposable by a strong heat.

D. The lithic acid exists in human urine; forms the stone in the bladder; is dry, crystallized in flat needles almost insipid and insoluble, in part volatile, decomposable by a strong heat; yields ammoniacal carbonate and Prussic acid when heated with fire; forms with nitric acid, a solution of a beautiful red colour; is soluble in caustic alkali; is precipitated from the urine of persons under fever, with a reddish or greyish colour.

E. Formic acid is extracted from ants or *formicæ*, by distillation, or squeezing with water; reddens blue flowers of vegetables, even in the living insect; is evolved in a strongly odorate vapour; in its smell resembles musk; kills animals, in this gaseous form; is fit for the same domestic uses as vinegar; is decomposable by a strong heat; attracts oxigene from oxygenated muriatic acid; is often stronger than the sulphuric acid; forms with alkalis and earths crystallizable and non-deliquescent salts.

F. The bombic acid is preserved in a reservoir, situate near the anus of the chrysalis of the silk-worm; is extracted from this reservoir by compression, or by means of alcohol; is mingled,

mingled, in the worm with a brown oil and a gum; is liquid, of an amber yellow colour, spontaneously decomposable; yields Prussic acid by distillation, and with the nitric acid; is unknown in its combinations.

G. Prussic acid which saturates iron, and gives it the colour of Prussian blue, is at present obtained by the distillation of blood, by the action of the nitric acid upon the albumen, the gluten, or the fibres, &c. of animals; is evolved, while a formation of oxalic acid takes place; is remarkable for a foetid, noxious smell, resembling that of bitter almonds; is easily decomposable by a great heat, and on decomposition, yields ammoniac; is capable of assuming the form of gas; attracts metallic oxides from many of the other acids; may be formed by the union of hydrogen, carbone, azote, and oxigene; is slightly acid in its taste; and contains, as it should seem, but little oxigene,

XXII. From what is here laid down, it follows, that the acids which have been divided into two classes, as being simple or compound in their radicals; differ yet more essentially in this, that the acids of the former class, are not mutually convertible into one another; because there is a wide difference between the properties of one simple radical, such as sulphur, and those of another, as for instance phosphorus. To effect the mutual conversion of any two acids with simple bases, it would be necessary to begin with converting their radicals into one another; a change which art is far from knowing how to accomplish. The second class of acids, on the contrary, being, in general formed of a base compounded of hydrogen, carbone, and azote, and combined with oxigene, appear to differ from one another, only in possessing different proportions of the two or three principles in the composition of their radical; and in the proportion of the oxigene by which the radical is acidified. They have a tendency to experience continual variations in the proportions of their composition; especially



cially under the influence of change of temperature, moisture, &c.; and they thus pass spontaneously into different states. Thus, for instance, by the efforts of vegetation merely, plants come to contain different acids at different periods in their growth. Thus, solutions of vegetable acids in water, are altered, suffer a change of nature, and at last yield all, more or less of carbonic acid and water, when they reach the ultimate period of their decomposition.

XXIII. These truths being clearly comprehended, we cannot fail to perceive, that there remains yet to be discovered, not only the nature of several acids, the composition of which is unknown; but even the existence of perhaps a considerable number of new acids in plants and animals. For among the products of those organized beings, of which we have begun to investigate the principles, we are as yet far from having exhausted all the possible combinations of carbone, hydrogen, azote, and oxygen; as a very slight calculation will readily shew. To this order of researches and discoveries, is to be referred, the examination of those acids which are said to exist in cork, in grey pease, and in various vegetable matters, as also in the clot of the blood—*cruoric acid*, and in the gastric juice, &c. It will also be perceived, upon inspecting the particulars of the chapter immediately subsequent, that most metals, when burnt, appear to assume an acid character, and to act the part of acids in many combinations. Acid substances, therefore, seem to be the most numerous of all bodies, and to act the most important part in all those chemical alterations which bodies, simple and compound, incessantly undergo.

*Application of the above propositions.*

The artificial formation of sulphuric acid by the combustion of sulphur in the great way.

The extraction of colour from white linens and stuffs by sulphureous acid.

The

The new arts of bleaching, by the oxygenated muriatic acid.

Theory of the *Aqua Regia* of ancient chemists.

The art of engraving on glass with the fluoric acid.

Part of the theory of the formation of artificial nitre-works.

The existence and formation of the known native acids.

The influence of the acids in mineralization,

The extraction and purification of vegetable acids and acidula.

The spontaneous formation and destruction of vegetable acids.

The mutual conversions of those acids and acidula into one another by vegetation, fermentation, &c.

C H A P.



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## CHAP. VIII.

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### *Of the Union of the ACIDS with the EARTHS and ALKALIS.*

I. ALL the acids combine without decomposition, with the alkaline earths, and the alkalis. These combinations have been termed *neutral salts*, *middle salts*, *compound salts*, *secondary salts*. The two former of these names, are not correctly applicable to them, except when they are neither acid nor alkaline; the two latter are more accurate, and more useful. All these salts are easily formed by art. Nature exhibits a great number, especially of those which are formed by acids of simple radicals. Mineralogy is daily obtaining the knowledge of new salts of this character, by the analysis of minerals, which can alone explain their intimate nature.

II. All these compound salts require to be distinguished by two names; one expressing the acid; the other, the terrene or alkaline base. The first of these names may have two variations of termination, corresponding to two different states of the acid in the compound salt. The termination *ate* may be employed, when the acid is one of those which are completely saturated with oxigene, and whose names end in *ic*; thus the salts compounded with the *nitric* acid, may be called *nitrates*. Words terminating in *ite*, will serve to distinguish the

the presence of those weak acids which are not fully saturated with oxygen; and which when alone have names ending in *ous*; thus *nitrites* are salts compounded with the *nitrous* acid.

III. As there are thirty-four species of known acids, and seven bases, terrene and alkaline, susceptible of such combination as forms compound salts, the number of these compound salts might be stated at 238. But this enumeration would be far from accurate: 1. For there are but a few acids susceptible of combination with silices: 2. Because there are other acids, which, on account of their weakness, cannot, without undergoing decomposition, enter into union with terrene bases, or with ammoniac: 3. Because there are various acids capable of combining with the same bases in three different ways,—or of three different states of saturation with those bases; namely, with excess of acid, in the exact neutral state, and with excess of base. Neither can we exactly determine the number of the terrene and alkaline compound salts; for we are as yet far from having examined those combinations so fully as to know them well, and to be certain whether they may not be susceptible of various saturations, &c.

IV. As the acids have all different elective attractions or affinities for every different terrene or alkaline base; it would be necessary for us to know all these different affinities, in order that we might have a complete history of the compound salts. But only a small number of these affinities have hitherto been exactly determined: We are too far from possessing all the assemblage of facts, necessary to throw due light upon these bodies: We have not as yet thoroughly examined a tenth part of them.

V. To enter regularly upon the history of compound salts; we must divide them into genera and species, and ascertain their genera and specific characters. Of this part of the history of these salts, only a slight sketch can be here given; because chemists have hitherto paid small attention to it; although it be now of the utmost importance, to apply the methods of  
botany



botany to the enunciation of the chemical properties of these and other bodies.

There are two modes which may be employed for the systematic arrangement of the compound salts. Of these, one is founded upon the consideration of the nature of the acids; the other refers to the nature of the bases. We cannot as yet form genera which shall comprehend all these salts, otherwise than upon the nature of the acids; for the acids alone can furnish us with generic characters; the influence of the bases upon the properties of these compounds, is not yet so adequately known, as that we can employ these alkaline and terrene substances, as the heads of generic divisions.

VI. We may reckon five and thirty genera of compound salts, corresponding to the number of the acids. The generic names are taken from the acids respectively. The following are the denominations of the thirty-five genera.

- I. Genus, SULPHATES.
- II. Genus, SULPHITES.
- III. Genus, NITRATES.
- IV. Genus, NITRITES.
- V. Genus, CARBONATES.
- VI. Genus, PHOSPHATES.
- VII. Genus, PHOSPHITES.
- VIII. Genus, ARSENIATES.
- IX. Genus, ARSENITES.
- X. Genus, TUNSTATES.
- XI. Genus, MOLYBDATES.
- XII. Genus, MURIATES.
- XIII. Genus, OXIGENATED MURIATES.
- XIV. Genus, FLUATES.
- XV. Genus, BORATES.
- XVI. Genus, SUCCINATES.
- XVII. Genus, CITRATES.
- XVIII. Genus, GALLATES.

XIX.

- XIX. Genus, MALATES.
- XX. Genus, BENZOATES.
- XXI. Genus, TARTRITES.
- XXII. Genus, OXALITES.
- XXIII. Genus, CAMPHORATES.
- XXIV. Genus, PYROMUCITES.
- XXV. Genus, PYROLIGNITES.
- XXVI. Genus, PYRO-TARTARITES.
- XXVII. Genus, ACETATES.
- XXVIII. Genus, ACETITES.
- XXIX. Genus, LACTATES.
- XXX. Genus, SACCHO-LACTATES.
- XXXI. Genus, SEBATES.
- XXXII. Genus, LITHIATES.
- XXXIII. Genus, FORMIATES.
- XXXIV. Genus, BOMBIATES.
- XXXV. Genus, PRUSSIATES.

VII. Every one of these five and thirty genera of compound salts which are here enumerated, is to be considered, with regard to its distinctive characters, or to those properties which serve to distinguish it from every other genus, and to afford clear notions of those differences by which all the genera are mutually discriminated. We must, for this end, chuse out one single property if possible, or at the utmost, two or three properties, strikingly different from one another, in every genus; and thus find the peculiar characters of all the genera. The following is an attempt at this.

I. Genus, SULPHATES; decomposable by charcoal, &c. into sulphures.

II. Genus, SULPHITES; yield, by the contact of almost any acid, the smell of burning sulphur with effervescence.

III. Genus, NITRATES; kindle combustible bodies, at almost any temperature; and are almost all reduced to their base by the action of fire.

IV.



IV. Genus, NITRITES ; decomposable by weak acids which separate from them a red nitrous vapour.

V. Genus, CARBONATES ; in which the characters of the bases still remain more or less eminent ; and which, with all the acids, exhibit a brisk and discernible effervescence, that proceeds till the carbonic acid be wholly disengaged.

VI. Genus, PHOSPHATES ; decomposable mediately or immediately, by charcoal, which separates the phosphorus.

VII. Genus, PHOSPHITES ; all immediately decomposable by charcoal, which separates the phosphorus ; and affording vapours by the contact of the sulphuric acid, &c.

VIII. Genus, ARSENIATES ; yield by the contact of burning coals, the odour and the white vapour of arsenic ; are not decomposable by acids alone, or without a double affinity.

IX. Genus, ARSENITES ; the arsenious acid is separated and precipitated from their solutions, by the contact of any other acid,—even by that of the arsenic acid.

X. Genus, TUNSTATES ; become yellow at the contact of the nitric or the muriatic acid.

XI. Genus, MOLYBDATES ; these are to be known, as yet, only by their affording molybdic acid, when treated with other acids ; and by the peculiar properties of the molybdic acid.

XII. Genus, MURIATES ; yield muriatic acid, at the contact of the concentrated sulphuric acid ; and oxygenated muriatic acid, by the contact of nitric acid.

XIII. Genus, OXYGENATED MURIATES ; kindle all combustible bodies, at a lower temperature, than do nitrates, with a brisk flame ; and after this combustion, remain in the state of simple muriates.

XIV. Genus, FLUATES ; emit, at the contact of concentrated sulphuric acid, a vapour that corrodes glass.

XV. Genus, BORATES ; fusible, with or without the separation of their bases ; yield by solution, in union with another acid,—boracic acid in foliated crystals.

XVI. Genus, *SUCCINATES*; we cannot distinguish and characterise, without first decomposing them, and observing their acid; they for the most part retain a smell of burnt amber.

XVII. Genus, *CITRATES*; are not sufficiently known to be discriminated by generic characters; in order to distinguish them, we must separate the citric acid by the use of the strongest mineral acids.

XVIII. Genus, *GALLATES*; these are all very clearly characterised by the property which they possess, of producing a black precipitate from solutions of iron; and of effecting a partial reduction of the oxides of silver, gold, and mercury, —at the same time, when they separate them from their solutions.

XIX. Genus, *MALATES*; are almost all deliquescent; are to be distinguished only by a partial extraction of their acid, by means of mineral acids.

XX. Genus, *BENZOATES*; their genus may be determined by the smell which they emit of the benzoic acid; and by their affording this acid, when exposed to the action of other more powerful acids.

XXI. Genus, *TARTRITES*; we find characters sufficiently striking, to distinguish these salts, in their tendency to form triple salts, and acidula less soluble than the pure acid and the neutral salts which that acid forms with the same bases.

XXII. Genus, *OXALATES*; their tendency to form acidula scarcely soluble; and the property which they possess of decomposing all calcareous salts; are sufficient to distinguish them.

XXIII. Genus, *CAMPHORATES*; are too little known, for us to be able to assign them, generic characters; they are to be distinguished by the presence and the properties of the camphoric acid, partially obtained from them.



XXIV. Genus, PYROMUCITES; in the same case as the camphorates.

XXV. Genus, PYROLIGNITES; equally unknown.

XXVI. Genus, PYRO-TARTARITES; cannot be characterised.

XXVII. Genus, ACETATES; still but indistinctly discriminated from acetites; yield, when decomposed by mineral acids, a very strong, and a very pungent white vapour.

XXVIII. Genus, ACETITES; all to be distinguished by their acid, separated from the base by other more powerful acids.

XXIX. Genus, LACTATES; are very little known; distinguishable only in their acid, separated by other acids.

XXX. Genus, SACCHOLACTES; like the lactates, unknown.

XXXI. Genus, SEBATES; affording the white vapour, and the acrid odour of the sebacic acid, at the contact of the more powerful mineral acids.

XXXII. Genus, LITHIATES; in their attractions, the feeblest of all acids; decomposable even by carbonic acid.

XXXIII. Genus, FORMIATES; very little known, and only distinguishable by their acid.

XXXIV. Genus, BOMBIATES; not better known than the formiates.

XXXV. Genus, PRUSSIATES; clearly characterised by their power of forming Prussian blue, with solutions of iron.

VIII. To determine the specific characters of nearly 245 species which these thirty-five genera contain; they must be studied with deep and assiduous care. In this department, the science of chemistry, is not yet far advanced. Wanting such knowledge, let us at least endeavour to distinguish the path we must follow in order to complete the history of these compounds, and to fix a proper method of studying their properties.

Every

Every compound salt, terrene or alkaline, exhibits to the observer, the following particulars.

1. Form, and the varieties of form. These are to be geometrically described. The inclination and the degrees of the angles; the primitive formation of the crystals; their interior form; their dissection; and the laws of diminution which determine their varieties; ought to be all remarked and expressed.

2. Its existence in nature or art; the comparison of the native with the artificial salt.

3. Its taste.

4. The action of fire upon it; which may be either nothing at all, or fusing, vitrifying, sublimating, decomposing, &c.

5. The action of light.

6. The influence of air, which may be either negative, or such as to furnish or abstract water of crystallization.

7. Its union with water; the quantity necessary to its solution, at different temperatures; the caloric then absorbed or disengaged; the crystallization effected by cooling or evaporation.

8. The attraction of earths, modifying, decomposing, not affecting, or entering into a triple compound with—the salt.

9. The effect of the alkalis upon it, which may be negative, decomposing, or sometimes forming a triple compound.

10. The comparative action of the acids different from that existing in the compound salt; and this is either such as to decompose, and destroy the peculiar nature of the salt, or such as to produce no effect upon it.

11. The influence of the neutral salts upon it; which is either negative, or tending to form a triple salt by entire combination; or effecting a double decomposition by which the bases and acids are reciprocally changed; or producing a precipitation in consequence of the attraction of some of the substances for water.



12. The solubility or insolubility of the salt in alcohol.

13. Its alteration or inalterability by charcoal, decomposing its acid, or leaving it unaffected.

14. The influence of vegetation and fermentation upon this salt.

15. Its action on the animal œconomy.

IX. If in the present state of chemistry, all these inquiries could be satisfactorily answered; the history of the compound salts, terrene and alkaline, would then, not only be complete, but would throw great light on many of the phenomena of nature and art, which are, as yet, but little understood.

X. We are already acquainted with some saline combinations of an acid with two bases;—and these bases are more especially magnesia and ammoniac. Such compounds are denominated triple salts. But, there are probably many more of them than we yet suspect; and these demand all the attention of chemists. The earth exposes both at its surface, and in its cavities near the surface, various saline compounds differing from those which art produces,—in that the former alone exhibit the simultaneous existence of two bases, or even of two acids. Borate of lime, and borate of magnesia have been already found crystallized together in cubic quartz; sulphate of lime and fluuate of lime, in earth of Marmaroch, and stone of Estremadura, &c.

*Application of the foregoing propositions.*

The knowledge of native salts.

The crystallization and purification of useful salts.

The phenomena of solutions.

The precipitation and preparation of aluminés, magnesia, &c.

The

The attraction of lime, potash, soda, and ammoniac for acids.

The formation of neutral salts in nature.

All the particular facts relative to the manufacture of salts.

The preparation of the nitric, muriatic, boracic, &c. acids.



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## CHAP. IX.

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### OXIDATION and SOLUTION of METALS.

I. IN the sixth chapter preceding, we have considered metals as combustible bodies undecomposed or simple, and characterised by their more remarkable properties. But those general facts are not sufficient. The part which metals act among the phenomena of nature, and in the processes of art, requires us to examine them particularly, and in such detail, that we may rightly estimate the full extent of their varied influence.

II. Although metals be capable of mutual combination in their metallic state, as well as of union with sulphur, phosphorus, carbone, and with all combustible matters in general; yet they are more commonly combined with oxygen, before entering into combination with any other substances: Or, in other words, in order to enter into most of the compounds in which they are known to exist; they must first be combined with oxygen, or reduced to the state of burnt bodies. All the singular phenomena which the metals exhibit in their combinations; all the changes of form which they undergo; are owing to their attraction for oxygen, and to the varying proportions in which they possess this principle.

III.

III. Although there be many cases in which the metals are susceptible of combination with oxigene; yet these may all be reduced to three general heads. The first is *the contact of air*, assisted by the action of caloric; the second is owing to the *decomposition of water*; the third, to the *decomposition of acids*. In this threefold point of view, we shall here consider the oxidation and solution of metals.

IV. All metals heated in the air, and raised to a certain temperature, higher or lower, before or after their fusion, are liable to burn with a brisk flame, an ardent heat, and a real deflagration. They then absorb oxigene in a more or less solid state. Such as are oxidated slowly, and without any sensible inflammation, nevertheless disengage light and caloric from vital air; but in quantities so small, that the light and caloric do not, during their disengagement, become perceptible to our organs.

V. Rise of temperature favours the absorption of oxigene from the atmosphere, by metals; and renders the combination of this principle with these combustible bodies, more solid than it would otherwise be.

VI. While some metals burn in the air, only at a very high temperature,—such as gold, silver, and platina; there are others that burn at any temperature, even at the lowest and with the utmost readiness; such as manganese which is oxidated, and crumbles down into a powder, in the space of a few hours, by the contact of air merely, and this even several degrees under zero. Some metals, such as iron, copper, lead, &c. burn slowly, and in the course of a few months in the air, even cold.

VII. All metals increase in weight during this process, which never takes place without the access of air; and absorb a new principle of oxigene from the atmosphere, without losing any thing of their former substance. The name of *calcination* formerly given to this phenomenon, cannot now be retained; any more than the term *metallic calces*. The words



*combustion*, and *oxidation*, are now employed to express this process; as is the phrase *metallic oxides*, to distinguish metals which are burnt in it.

VIII. The colours which metals exhibit, as they burn, or with which their flame is tinged, appear to owe their origin to the solution of metallic particles in the light that is disengaged: thus copper affords a green flame, &c.

IX. Not only do all metals, compared with one another, in their combustion by the contact of air, absorb different quantities of *oxigene*, in order to their saturation; but likewise each metal considered by itself, absorbs various proportions, and stops at different points of oxidation, according as the degrees of its temperature vary. Thus tin, lead, copper, iron, change their colour, and are studded with the tints of the rainbow, at the lowest degrees of heat to which they are exposed in contact with air: lead first becomes a grey oxide, then a yellow, and at last a red oxide; mercury passes from black to white, from white to yellow, from yellow to red; iron at first a black oxide, becomes next a green, then a brown, and at last a white oxide; copper is first a brown oxide, then a blue, and in its last degree of oxidation, takes a green colour.

X. The metals differ all from one another, in their attractions for *oxigene*. There are some, which light, almost alone, and with very little caloric, is able to deprive of their *oxigene*, such as gold, silver, &c. Others require in order to separate the *oxigene*, a great degree of heat, and much light; such as mercury. Lastly, most metallic oxides do not yield their *oxigene* to caloric and light alone, and unassisted by other matters. To decompose these last oxides, they are heated with charcoal which deprives them of their *oxigene*.

XI. In consequence likewise of this diversity in the attractions of the metals for *oxigene*, some metals will abstract the *oxigene* from the oxides of other metals; almost any other metal detaches *oxigene* from gold or silver; copper detaches

it from mercury, iron from copper, &c. These attractions are not, as yet, all well known. What we do know of them, indicates the following to be the order of the attractions of these several metals for oxigene; beginning with that which is the strongest; manganese, zinc, iron, tin, copper, mercury, silver, gold.

XII. Several metals decompose water; and accomplish this so much the more sensibly or rapidly in proportion as their temperature is higher; because then the great quantity of the caloric employed, more powerfully attracts and dissolves the hydrogen. Thus fire decomposes water with great energy, at a white-red heat; but cannot effect the same decomposition otherwise than very slowly at even the highest temperature of the atmosphere.

XIII. Iron, zinc, tin, antimony appear to be capable of decomposing water. Probably, manganese, and even some other metallic substances are equally capable of accomplishing the same effects. This decomposition is owing to an attraction in the metal for oxigene, stronger than that of oxigene for hydrogen; and in consequence, the oxides of those metals which do not decompose water, are liable to be wholly decomposed by hydrogen. But here we must distinguish among the different degrees of oxidation: for oxide of iron highly oxidated, namely to a brown colour, is partly decomposed by hydrogen, and restored to the state of a black oxide; as iron abstracts oxigene from water only till it be oxidated black: Beyond this state of oxidation, iron is unable to decompose water.

XIV. All metals capable of decomposing water, effect this decomposition much more easily and entirely, when they are aided by the contact of a body that has a great tendency to combine with their oxides. It often happens, even that metals, like other combustible bodies, which would not alone decompose water, become capable of effecting this decomposition, in consequence of the presence of some other substances, which act by a disposing affinity. Thus the presence of acids,  
renders



renders almost all metals capable of effecting the decomposition of water.

XV. Metallic oxides have this peculiar in their combinations, that they seem to perform the functions of alkalis or of terrene and alkaline bases, in respect to the acids ; although they be, on the other hand, capable of combining with earths and alkalis, as if they were acids. There are indeed fewer of those oxides that incline to act the part of acids, than of those which are fitter for bases to compound salts ; and it is observed, in general, that the oxides to which oxigene adheres the most tenaciously, are those which saturate alkalis in the manner of acids ;—such as the oxides of antimony, lead, iron, and manganese. It has been already related in the VI. chapter, that there are three metals actually acidifiable.

XVI. The metals cannot be dissolved by the acids, without being previously oxidated. On this account, metallic oxides soluble in acids, dissolve in them slowly and without effervescence : but metals are not soluble in the same menstrua, without movement and effervescence.

XVII. The effervescence produced by the solution of metals, is owing to this cause, that when they absorb the oxigene, they detach it from a principle which then assumes the form of a gas or elastic fluid. This principle proceeds either from water or acids, according as the one or the other of these is the substance decomposed. Sometimes it originates from both these bodies at once ; and then they are both decomposed by the metal together.

XVIII. The sulphuric acid thus decomposed by metals, if it be concentrated, yields sulphureous gas : Nitric acid, upon the same occasion yields nitrous gas.

XIX. The sulphuric acid, diluted in water, greatly promoting the decomposition of the water by metals, yields, in this case, gas hydrogene. Solutions of zinc and iron in the aqueous sulphuric acid, act chiefly in this way. The phosphoric

phoric acid exhibits with metals, nearly the same phenomena, as the sulphuric acid.

XX. The nitric acid is not only decomposed by various metals, but even suffers the water in which it is diluted to be decomposed at the same time as itself. In order to this it is enough, that the metal dissolved in the acid, be extremely greedy of oxygen, as is tin. The hydrogen of the water, in this case, combining with the azote of the nitric acid, forms ammoniac; and hence these solutions afford no gas, but are found to contain ammoniacal nitrate. From this it may be understood, how most solutions of white metals in nitric acid, come to afford vapours of ammoniac, when quicklime is cast into them.

XXI. The muriatic acid not being susceptible of decomposition by combustible bodies, can by itself dissolve, but few metallic substances. It acts only on those metals which are so greedy of oxygen, as to decompose the water in which it is diluted. While metals are dissolved by the muriatic acid, there is always a considerable quantity of hydrogenous gas disengaged.

XXII. Not only is the muriatic acid unsuspceptible of decomposition by the metals; but it possesses likewise the property of absorbing oxygen from almost all metallic oxides. It passes upon this into the state of oxygenated muriatic acid. To its attraction for oxygen does this metal owe the property it possesses of dissolving metallic oxides with facility: and it is on this account employed successfully to dissolve oxide of iron on which the other acids do not act. If metallic oxides supersaturated with oxygen be dissolved in muriatic acid, the acid effervesces; a part of it then passing into the state of oxygenated muriatic acid gas. If these oxides be oxygenated only to that degree which is requisite for their combination with the acid, they will then dissolve without emotion, and without effervescence, as salt or sugar in water.

XXIII.



XXIII. The boracic and fluoric acids combine but weakly with metallic oxides. They are incapable of dissolving pure metals, because they are not decomposable by these bodies. Yet with water, they produce the oxidation of those metals which have the strongest affinity for oxygen. The same is the case with the carbonic acid, which combines readily with most metallic oxides, and in nature is often found in union with them.

XXIV. The metallic acids are easily decomposed by the most combustible of the metals. They combine readily with the oxides; and in nature, are often found thus combined.

XXV. The vegetable and animal acids, which have radicals composed of hydrogen and carbon, are not decomposed by the metals, but render water highly decomposable by these bodies; and combine in a state of sufficient solidity, with the metallic oxides. Several of them, reduce these oxides to the state of metals.

XXVI. The metallic oxides cannot combine with acids, or remain in union with them, unless in consequence of containing certain determinate proportions of oxygen. Under these proportions, the combination cannot take place; if the due proportions be exceeded, the substances combined, cannot remain in union.

XXVII. Beside this general truth; there is another of the same order, which relates to each metal and each acid in particular. And this is, that the acid and metal cannot remain in union, otherwise than within the often straitened limits of oxidation. There is a determinate proportion of oxygen in the combination of an acid with a metallic oxide.

XXVIII. It is in virtue of this law, that metallic solutions exposed to the air, yield a precipitate, and become turbid, in proportion as the metallic oxide absorbing oxygen from the atmosphere, becomes gradually insoluble in the acid. This is the ratio of those decompositions which are accomplished

plished by the atmosphere, upon most metallic sulphates and nitrates.

XXIX. Nay it often happens, that metallic oxides dissolved in acids, gradually re-act upon these salts, and abstract from them, even in close vessels, and in contact with air, a portion of their oxigene, so that the oxide is soon separated from the acid, and is precipitated to the bottom of the solution.

XXX. Heat is singularly favourable to this successive decomposition of acids by metallic oxides. Thus nitric solutions become turbid, or more and more decomposable, by the action of air and water, if they be at the same time heated. This is particularly remarkable in the case of the nitric solution of mercury.

XXXI. Some metals have so great a tendency to oxidation by acids, that they can neither remain in union with them, nor yet form permanent solutions. Such are, particularly those which possess the property of becoming acid or forming oxides susceptible of combination with alkalis; arsenic, tungsten, molybdena, antimony, tin, iron, &c. Solutions of these metals, in nitric acid especially, are always charged with precipitates, and contain little or no metallic oxide.

XXXII. From these facts it appears, that, in order to form metallic salts, the metallic oxides must remain permanently in union with the acids, without having any tendency to separation. It is also necessary, that care be taken not to augment their affinity for oxigene; and to avoid bringing this principle into contact with them.

XXXIII. Compound metallic salts always, or almost always, possess an excess of acid. They are otherwise, all more or less acrid and corrosive; which shews that almost all metallic oxides have a tendency to become acid.

XXXIV. Those properties of metallic salts which it is of consequence for us to know, may be reduced under the following heads. 1. Form and its varieties; 2. Taste and causticity, more or less considerable; 3. Alteration by light;



4. Fusion, deficcation, decomposition more or less perfect, by caloric; 5. Deliquescence, efflorescence, or decomposition, more or less entire, by means of air; 6. Solubility in water, hot or cold, decomposition more or less thorough, by pure water, &c.; 7. Decomposition by alkalis and earths, the nature of precipitated metallic oxides, the complete precipitation or formation of triple salts, partly alkaline or terrene, and in part metallic; 8. The alteration of precipitated metallic oxides at the moment of their precipitation, either by air, or by the nature of the alkali employed, as in the case of ammoniac; 9. Reciprocal alteration by different acids, decomposition or the contrary, attraction of acids by metallic oxides, the changes of oxides which are distinguishable by their colours; 10. Alteration by the neutral salts, terrene or alkaline, which exhibit either an union without decomposition, or a double decomposition; 11. The reciprocal action of metallic salts upon one another, which displays either a simple union, or a simple change of bases by the acids, or a change in the combination of the oxigene by which the two oxides are precipitated;—the one partially *de-oxidated*; the other *super-oxidated*;—and such for instance, is that useful precipitation of the muriatic solution of gold by the muriatic solution of tin, which furnishes the *purple precipitate of Cassius*; 12. Union with the terrene or alkaline sulphures, and the formation of the different sorts of sulphureous ores.

XXXV. Metallic oxides differ from one another in the degrees of their affinity with acids; so that some of them may be employed to decompose the combinations of others. But above all, the varying affinities of the metals with oxigene, act as the principal cause of the phænomena of the precipitation of metallic solutions: Thus different metals, while they take away the oxigene from other metals dissolved in acids, cause these last, to appear again in the metallic form; as copper, for instance, does with mercury, mercury with silver, iron with copper, zinc with iron, &c. Sometimes the metals do

not detach all the oxigene from the metallic oxides dissolved in the acids. This happens when the precipitating metals do not require all the oxigene of the metals in solution: Thus tin, when precipitating oxide of gold, does not absorb all the oxigene which that oxide contained, but suffers the gold to be precipitated in a particular state of oxidation. Metallic oxides when they thus share the oxigene between them in new proportions, are precipitated with properties that deserve to be better observed, than they have hitherto been.

*Application of the general facts in this chapter.*

Preparation of all the metallic oxides used in the arts.

Coloured glasses, enamels.

Metallic salts useful in the arts.

Effects of these salts in the arts in which they are employed.

Solutions, and partings of metals.

Precipitation of metallic oxides by earths and alkalis.

These applications are in general so various and so useful, that they cannot be explained in detail, elsewhere than under the particular history of each different metal.



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## CHAP. X.

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### FORMATION *and* NATURE of VEGETABLE MATTERS.

I. THOSE matters which compose the texture of vegetables, differ from mineral substances, in being of an order of composition which is more complex, and in being all highly susceptible of decomposition or analysis, while none of them is susceptible of synthesis.

II. Only the substantial contexture of living vegetables, only their vegetative organs—can form those matters which are extracted from them; no instrument of art is capable of imitating those compositions that are continually effected in the organized frames of plants.

III. Although it be with four or five natural substances, caloric, light, water, air, and carbone, extracted from the remains of plants, which have been crumbled down and blended in the soil; that vegetables elaborate all the materials of which their contexture is formed; yet, do we find a wonderful variety of properties in these materials. We may, however reduce all these properties to a certain number of heads, under the name of *the immediate principles of plants*; because these principles are obtained by simple processes, almost entirely

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ly mechanical, and by a sort of immediate analysis that produces no alteration of their nature.

IV. These matters, being more or less compound, are lodged in particular organs, or in distinct vessels or cells, &c. Sometimes their seat is in the root or in the stem, in the bark and the leaves all together: At other times, on the contrary, only the flowers, fruits, or seeds, and even some particular parts of these organs, contain the immediate principles. This varying situation of these immediate principles, shews the differences in the organization of the texture to be the cause of that diversity of nature which each of these matters displays.

V. The different place occupied by each of the different materials of vegetables, is often such as to permit us easily to obtain them pure and separate. Where such a distribution takes place, it is sufficient to bruise or open the vessels or cells containing the immediate principles, to open them, or to squeeze out the liquid juices. Nature, by the sole force of vegetation, often presents this separation already effected, on the outside of plants. Thus manna, gum, resins, &c. flow spontaneously. Art is often obliged to separate some of these materials from the confusion in which they are mingled and united with various other matters. The means she employs for this, are usually simple, and easily practised; such as rest, filtration, pressure, washing, distillation by a gentle heat, none of which, alters the substances subjected to it.

VI. Among the materials which compose the frame of vegetable bodies; which are obtained from them by simple means that alter not their nature; and which are either fluid or solid; may be reckoned the following substances,

1. The extractive matter, or extract.
2. The mucous matter, or mucilage.
3. Sugar.
4. Essential salts.



5. Fixed oil.
6. Volatile oil.
7. Aroma.
8. Camphor.
9. Resin.
10. Balsam.
11. Gum resin.
12. Feculum.
13. Gluten.
14. Colouring matter.
15. Gum elastic.
16. The ligneous part.

Beside these sixteen principles, there is found in the analysis of vegetables, a substance resembling the albumen in the animal kingdom. It is probable that there are several other vegetable principles still unknown; such as the matter which serves for tanning hides, &c.

VII. It is proper, that the reader here fully understand, that, when all the facts in the analysis of vegetables, have been reduced to general terms or leading results; there has been nothing more found in any of all the plants hitherto examined, but the foregoing eighteen substances. These actually compose the contexture and fabric of all known vegetables; and when these are separated from any vegetable, that vegetable is very accurately analysed. Yet, we are not to suppose, that these eighteen immediate materials exist in all the different parts of vegetables, or even in every different vegetable. Some plants, out of all their parts, afford not even so many as five or six of these materials; others contain eight or nine of them; some yield them all. But, supposing, that we could mix together, and confound, even chemically, all those plants which are subjected to any chemical processes; the mixture, however seemingly various, would not exhibit more than the sixteen or eighteen substances above enumerated, as the

the results of the most exact and elaborate analysis. Vegetables may therefore be said to be formed of those immediate materials.

VIII. Each of the materials above mentioned, possesses peculiar distinctive properties, from among which we must select those which may the best mark their different characters, and discriminate them, one from another. It is not impossible to handle this subject in the manner of the botanists; using but one characteristic or specific phrase, to distinguish each of the materials of which we speak. Although this method have not as yet been either proposed or executed in chemistry; we shall endeavour to give a sketch of it in the subsequent sections; as has been already done in the case of the acids, and the compound salts.

*Characters of the immediate materials of vegetables.*

IX. *Extractive matter* or *extract*, is a dry, brown matter, somewhat deliquescent, soluble in water; is obtained from the inspissated juices of vegetables, from infusions, and from decoctions evaporated; yields by distillation, an acid, a little ammoniac, and some oil; absorbs oxigene from the atmosphere, and becomes gradually insoluble, in consequence of this absorption; is erroneously regarded as a natural soap; is compounded of carbone, hydrogen, azote, and oxigene, and has always a tendency to absorb more of this last principle, than it contained in its primitive state.

X. *Mucous matter* or *mucilage*, is a glutinous, viscid, insipid substance, which yields pyro-mucous acid by distillation; is soluble in water cold or hot; does not absorb oxigene from the atmosphere; becomes dry and brittle in the form of gum; exists in the roots, the young twigs, and the leaves; is obtained by expression from the bark of trees; connects their fibres together as they grow.



XI. *Sugar*, is of an agreeable, pungent taste, crystallizable, soluble, fermentible, in all respects very like to mucilage, but differing in its susceptibility of fermentation, and of forming alcohol. Mucilage and sugar are both compounds of carbone, hydrogen, and oxygen; and they differ from extract; 1. In having a smaller proportion of hydrogen;—in consequence of which, they do not, like extract, absorb oxygen from the atmosphere: 2. In being destitute of azote, owing to which, they yield no ammoniac by distillation.

XII. *Essential salt*, comprehends the vegetable acids which are in general formed of hydrogen and carbone more copiously oxygenated than in the three foregoing ingredients: and in consequence of this, the addition of oxygen to those ingredients, converts them into acids. The vegetable acids, in whatever number they may be, appear to differ from one another in nothing, save the proportions of their three principles. They are all decomposable by fire, and susceptible of mutual conversion into one another; and in an ultimate analysis, they are all reducible upon the addition of oxygen, to water and carbonic acid. (See title VII.)

XIII. *Fixed oil*, was formerly named *fat oil*; is thick, mild, inodorous; burns when volatilized; forms soaps with the caustic alkalis; is mixed with a mucilage which Scheele calls the *mild principle of oils*; is thickened and concreted by the contact of air, and the absorption of oxygen; suffers the same effects from acids and metallic oxides; is compounded of carbone, hydrogen, and a small proportion of oxygen. It differs from the preceding compounds, in possessing a larger proportion of hydrogen. Hence its combustibility, and tendency to change into water and carbonic acid, when it is burnt with a sufficient quantity of air; as in matches which are hollow, and surrounded on all sides with air; forming lamps with an interior current of air.

XIV. *Volatile oil*, called also *essential oil*, and *essence*, is acrid, highly odorate, wholly reducible to vapour at the heat

heat of  $212^{\circ}$  F.; does not readily combine with alkalis; is inflammable by acids; is inspissated by oxigene to a resin; burns more rapidly than fixed oil, and affords more water; suffers an easier precipitation of its charcoal, which then forms lamp-black.

XV. *Aroma*, otherwise called *spiritus rector*, is a very volatile principle, reducible to vapour by the heat of the atmosphere, and forming a peculiar atmosphere around plants; distillation of the plant on a *balneum maria*, affords the aroma together with water; sometimes aroma is of an inflammable nature; it presents in other instances, saline properties; it combines with alcohol, fixed oils, vinegar, &c. and in these combinations, forms what in pharmacy is called *distilled waters*; it contributes by its presence to the quantity of volatile oils, that is obtained from plants, and has so great a resemblance to these oils, that the one has been often mistaken for the other. The intimate nature of aroma is not yet exactly known. We begin to think, that it may be a peculiar substance, a solitary principle disengaged from vegetable matters; while these matters themselves are at the same time, entirely reduced to vapour.

XVI. *Camphor*, is a matter now known to exist in many vegetables; is to be reckoned one of their immediate principles; is of a concrete and crystalline form, highly volatile, combustible with smoke, soluble in a great quantity of water, in alcohol, and in æther; exists in many volatile oils; is contained, in purity, in the trunk and leaves of a sort of laurel from which it is ordinarily obtained; is very little known, as to its intimate nature; forms with nitric acid, a new and peculiar acid.

XVII. *Resin*, is a matter, soft or dry, scarcely odorate, combustible, soluble in alcohol, but not in water; scarcely alterable by acids, hardly susceptible of union with alkalis; is obtained from an inspissated volatile oil, from which it seems to differ only in possessing a larger proportion of oxigene.



XVIII. *Balsam*, is resin combined with benzoic acid, more highly odorate than pure resin; is deprived of its concrete acid by the action of fire and water; yields this acid to earths and alkalis; becomes after the loss of the acid, not unlike to resin.

XIX. *Gum-resin*, is a concrete juice, partly soluble in water; forms with water, a sort of emulsion as well as with vinegar, which has been supposed to be its universal solvent; is more soluble in alcohol; does not flow naturally, like resin, from vegetables, but is obtained from their vessels bruised, in the form of a white or variously coloured juice, of a fetid odour, more or less resembling that of garlic.

XX. *Feculum*, is a pulverulent, dry, white, insipid, combustible matter; yields by distillation, a large proportion of pyro-mucous acid; is soluble in boiling water; forms with this liquid, a jelly; is convertible into oxalic and malic acid by the action of the nitric acid; exists in all the white and brittle matters of vegetables, particularly in tuberculous roots, and in the grains of gramineous plants; forms the basis of the nourishment of animals; and is disposed to become with sufficient rapidity, a component principle of their bodies.

XXI. *Gluten*, is a substance, elastic, ductile, seemingly fibrous or membranous, insoluble in water, slightly soluble in alcohol; yields by distillation a large proportion of ammoniac; is putrescible like an animal substance; takes like animal substances, a yellow colour, upon the contact of nitric acid; is convertible by nitric acid into oxalic acid; and existing particularly in the flour of wheat, forms the difference between this and flour of other grains, by giving to the former, the property of composing a paste.

XXII. *Colouring matter*, goes always along with the one or the other of the preceding materials; appears to vary in its nature,—being sometimes soluble in water, and sometimes subject only to the action of alkalis, oils, or alcohol;

owes its diversified properties to different quantities of oxygen fixed in it; has an affinity for combination with aluminas, oxide of tin, &c. is capable of more or less perfect combination with the contexture of bodies animal and vegetable.

XXIII. *Gum-elastic*, resembles gum-resin; appears to exist in many vegetables; is remarkable for the ductility and elasticity which it retains, when dry; affords ammoniac by distillation; diffuses a foetid odour when burnt; exists at first in the form of a white, lacteous fluid, and passes into the state of gum elastic by absorbing oxygen from the atmosphere.

XXIV. *The ligneous part, or wood*, a matter that has been hitherto too much neglected by chemists, forms the solid base of all vegetables; but is by much more copious in those which are hard, than in such as are soft; has been erroneously regarded as an earth; is insoluble in water; affords by distillation that particular acid which is called pyro-ligneous; contains a great quantity of carbone; passes into three or four different acid states, by the action of nitric acid; appears to be the last product of vegetation.

XXV. From what has been above explained concerning the immediate and known materials of vegetables, it follows; that they are all reducible in a last analysis, to three or four principles, the principles, the primary components of them all; namely, hydrogen, carbone, oxygen, and in several of the above materials azote; and that those materials differ from one another only in the diversity of the proportions in which they severally contain the elementary constituents. But, if by simple calculation, we endeavour to find the number of different compounds that may result from such combinations, in all the possible proportions of three or four primary principles, we shall find, that a much greater number of them may easily exist. Yet, as every one of the ternary or quaternary compositions which form the immediate



materials of vegetables, admits, as it should seem, a certain latitude in the proportions of its principles with which it will still retain its general character of extractive, mucous, oil, acid, resin, &c. &c.; it is natural to infer, that the various proportions of the elementary principles, comprehended within those latitudes, must determine the vast, unmeasurable variety of colour, smell, taste, and consistency, which is well known to distinguish all the materials of vegetables; and which is universally observed in the component parts of those vegetable matters which are in common use for human food, clothing, buildings, &c.

XXVI. Upon the same consideration, it will be easily conceived, that vegetables must differ in the nature and specific properties of their materials, according to the different periods in the advancement of their vegetation; that they can never remain long in the same state; and that the diversified scenes which the periods of germination, foliation, blossoming, fructification, and maturation, the successive æras of vegetable life, exhibit, must necessarily be accompanied and discriminated by internal changes, corresponding to the variation of external appearances. Taste in all its varieties of modification, smell which is no less variable, and those diversities of contexture and consistency which distinguish the different periods in the progress of vegetation, are so many incontestible proofs of this.

XXVII. It is a new advantage derived from the improvements of modern chemistry; that we are now enabled to discern the nature of the materials of plants, which is more complex than that of mineral substances. This acquired knowledge leads us to an estimate of the changes which vegetable matters suffer from different chemical agents. We can no longer say that we are ignorant of the manner in which the destructive agency of fire operates upon vegetable substances. From the considerations here stated, it appears, that when a vegetable, either entire or in its separate products,

is submitted to the action of fire ; the caloric tends to reduce those complex compounds to compounds of a more simple character, by combining their principles, by two and two, in proportions widely different from those in which they before existed together. By heating vegetable products gently, we disengage the hydrogene which burns alone, and leaves a large residue of carbone ; when they are strongly heated, the carbone is disengaged together with the hydrogene ; both burn together in the air ; and the only residue left, is a small portion of earth and salts forming vegetable ashes.

XXVIII. All the immediate principles of vegetables, are then reducible in an ultimate analysis, to three or four primary principles, namely, hydrogene, carbone, oxigene, and a little azote in some of them : This analysis corresponds accurately to the manner in which vegetables are nourished, grow, spread out, and preserve their existence ; since we know that nothing but those simple principles is required to support vegetation :—We have therefore nothing farther to investigate, but the manner in which plants appropriate to themselves these elements, and the means by which they combine by their organic functions ;—in order to enable us to form by compositions, those substances of which the properties have been explained.

XXIX. There seems to be no doubt but that water affords the hydrogene of vegetables ; that they decompose water in their leaves, aided by the contact of solar light ; that they absorb the hydrogene of the decomposition, which is fixed in them, in the state of oil, or extract, or mucilage, &c.; and that they evolve the oxigene, of which a great part is fused by light and caloric, and disengaged into the state of vital air. But, a portion of the oxigene of the water thus decomposed, is at the same time fixed in the contexture of the vegetable, and is retained there, particularly by the attraction of the carbone.

XXX.



XXX. It is not so easy to give an account of the origin of the carbone which exists in vegetables. Some naturalists think that vegetables decompose carbonic acid at the same time as water, and absorb the carbone. This assertion is without proof; although it has gained new authority since the discovery of the decomposition by phosphorus of the carbonic acid combined with soda. Other chemists think, that vegetable earth, *humus*, dunghills, and especially water from dunghills afford carbone divided, or even dissolved in water; that plants absorb this principle by their roots, and do not abstract it from carbonic acid. According to this opinion, dung affords nothing but carbone; and the water of the dunghill is but a saturated solution of this principle. To these data must the chemical theory of vegetation be confined, until it shall be enlarged by farther investigation and experiment.

*Application of the general truths in the tenth chapter.*

These general truths are applicable to a very great variety of cases in nature and the arts. They respect agriculture, rural œconomy, pharmacy, materia medica, and all those arts which are employed upon vegetable substances. The following are a few of the most important cases of their application.

Germination.

The unfolding of the leaves of vegetables.

The blossoming of vegetables.

Fruetification,

The ripening of fruits and grains.

The successive formation of gum, extract, oil, resin, salts, sugar, colouring matter, wood, in the different periods of the life of a plant.

The growth of the ligneous substance, of the bark, &c.

Pharmaceutical

Pharmaceutical preparations of juices, extracts, essential salts, mucilages, oils, resins, gum-resins, aromatic waters, &c.

The arts of the sugar-boiler, the confectioner, the miller, the baker, the starch-maker, the vine-dresser, the brewer, the distiller, the varnisher, the dyer, the paper-maker, the indigo-maker, the colour-man, the flax-dresser, the oil-man, the soap-boiler, the perfumer, the charcoal-burner, &c.

**CHAP.**



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## CHAP. XI.

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### *Of the FORMATION and the NATURE of ANIMAL SUBSTANCE; THEORY of ANIMALIZATION.*

IT is a certain truth, that animals cannot support their existence, without the use of vegetables. In natural history, it has long been said, that vegetables are formed from minerals, animals from vegetables. But if this truth have been long known; yet the manner in which these bodies are mutually changed one into another, remains still unascertained. This however is the grand subject upon which, above all others, the labours of the chemist ought to be employed. This problem once solved, we shall obtain an exact knowledge of every thing respecting the animal œconomy. Modern discoveries afford already a variety of results which must be useful in these important researches.

II. The surest means for resolving this problem, is undoubtedly, first, to discriminate accurately between the different animal substances; to compare them with the peculiar matters of the vegetable kingdom; and carefully to examine the difference or resemblance subsisting between the two classes. There is no doubt, but that, if these differences were once well known; we might then discover the causes to which they are owing.

III. Collecting the results of all the analyses that have been lately made of the blood and humours, and of the solid parts of the human body which are evidently formed by the concretion of the fluids ; we shall find the most striking differences between animal and vegetable substances, to be the following.

A. The property in animal substances of affording ammoniac and fœtid products, when acted upon by fire.

B. Their property of putrefying more easily, and more rapidly, and of emitting an odour much more noisome.

C. Their yielding much more of gas azote, when acted upon by nitric acid.

D. Their contributing in a singular manner to the formation of nitric acid.

IV. All these differences seem to depend upon the existence of a particular principle which is azote, in much greater abundance in animal than in vegetable bodies. It should seem then, that the addition of azote to vegetables, might fully assimilate their nature to that of animal matters.

V. It is however to be farther observed, that to these primary and *capital distinctions* between animal and vegetable substances, there are other particular phænomena to be added ; the influence of which, although, no doubt smaller upon the animal compound ; is yet, not to be neglected. Such, among others, is the presence of the phosphoric acid, and of different phosphates, particularly phosphates of soda, lime, and ammoniac, in animal humours. To these salts is owing the peculiar quality, and the almost incombustible character of the coal of animal matters.

VI. That particular principle which is so copious in these substances, and which especially establishes the grand distinction between them and vegetable substances, namely, azote, appears therefore to be the efficient cause of the properties by which animal matters are distinguished ; and particularly of that



that sort of concreteness or elasticity, of which we shall soon have occasion to speak more at length. It may be affirmed therefore, that if animal matters be deprived of their azote, they may be reduced in some measure, to the character of vegetables; and that to convert vegetables into animal substances, it will be sufficient to introduce into them, or combine with them a due quantity of azote.

VII. We may consider all matters forming the bodies of animals as so many immediate principles; just as we represented the materials of vegetables. And each of those immediate principles of animal bodies may be characterised by the exposition of its most eminent properties. By thus examining and distinguishing blood, milk, bile, fat, urine, &c. as well as the solids of animals; and by describing them with that brevity which we have exhibited in the foregoing chapter; we shall form a sort of comparative scale that will indicate those resemblances and differences which we wish to know.

VIII. *The blood* is a red fluid; hot at the temperature of  $104^{\circ}$  F. in man, in quadrupeds, and in birds,—and in oviparous quadrupeds, serpents, and fishes, at the mean temperature of the places of their habitation; concretes by cold, miscible with water; separates almost spontaneously into three different substances, *white serum*, *red serum*, or the colouring part, and *fibrous matter*; exhibits in each of these matters distinctive characters,—in the white serum, an alkaline nature, and owing to the intimate combination of oxygen in it, a disposition to coagulate by fire, metallic oxides, &c.—in the red serum, the same general nature, differing from the white serum only in having oxide of iron present in it,—in the fibrous matter, or *fibrina*, spontaneous concreteness, and solubility in alkalis. These principal characters are to be considered as belonging to the whole blood, which seems to be the primary principle of all other animal substances, and the common source of all the humours, and all the solids. It has been called *fluid flesh*, on account of the *fibrina* which is concreted

concreted by cooling. The cause of its heat has been ascertained to exist in the alteration and absorption of vital air by respiration. The renovation of the blood by the chyle, and the change of the chyle into animal matter, have also appeared to be owing to the disengagement of a great quantity of carbone and hydrogene in the lungs.

IX. *Milk*, is a white fluid, mild and saccharine, formed of serum, cheese, and butter intermingled; and representing a genuine animal emulsion. In the serum of milk, there is to be particularly observed, that matter which is called *sugar of milk*, and has the character of a sort of incipient sugar. Another thing particularly worthy of careful notice, in milk, is the quantity of phosphate of lime, much larger than in any of the other humours, which is found in it; and which seems to indicate, that it has been the intention of Nature, to place in the first nutriment designed for animals, a large quantity of that osseous base which is necessary for the formation and growth of the bones in the first stage of life. Cheese is simply albuminous matter. Butter is a concrete oil, the solidity of which, and its easy separation from milk by motion only, appear to be owing to the absorption of oxigene from the atmosphere during the formation of the cream.

X. *Bile* is an oily, saponaceous juice, compounded of an oil nearly in the state of the white of the whale, and of soda united with this oil, and these mixed with the albuminous liquid formed in the liver, which viscus itself contains a great quantity of oil. Every thing in the system of this bulky gland, concurs to discover a disposition, an organization destined by Nature to separate from the blood, that great excess of fat which is produced by the slow circulation of this fluid through the venous system of the lower region of the belly. This consideration which must hereafter form one of the principal bases of chemical physiology, accounts for the bulk of the liver in a foetus in which respiration has not yet commenced, and in those animals which have not respiratory organs,



gans, such as man, birds, and quadrupeds have. It likewise explains the origin of some diseases of the liver, particularly of biliary stones or concretions.

XI. The *grease* or *fat*, is a sort of oleaginous matter formed at the extremities of the arteries, at the farthest possible distance from the centre of animal heat and motion; forms a sort of reservoir, in which that large quantity of hydrogen is fixed, which the lungs are unable to evacuate; is an oil combined with a considerable proportion of oxygen, and containing, besides, sebacic acid. To consider fat in this light, is, a point singularly striking in the chemical physiology of animals.

XII. *Urine* is an excrementitious fluid, more or less coloured, acrid and saline, remarkable for the great quantity of uncombined phosphoric acid, of phosphate of soda, of ammoniac and lime which it contains; still more remarkable for containing a peculiar acid which has not as yet been found in the rest of the animal humours; and which is now named *litbic acid*; because it forms the base of calculi in the reins or bladder, in the disease called *litbiasis*.

Some of the most valuable discoveries of chemistry respect the urine; medicine has still discoveries to make concerning this excrementitious fluid. Considering it, in the first instance, as a lixivium intended by Nature, to convey out of the body, a great quantity of saline matters which would otherwise prove noxious to the vital functions: we are hence led to perceive, in the next place, that, in the urinous evacuation, the proportion of the principles will vary with the state of the body, and thus will become a sort of measure indicating by its varying modifications, the health or sickness of the vital frame. Physicians have already successfully begun their observations upon this matter. The urine is to be regarded as containing always the matter of concretions in the reins or bladder. These concretions require to their formation, nothing but the detention of this matter, a longer time than

Nature has designed, in its proper organs, on an incipient nodule on which successive concretions may be from time to time deposited. The proportions of the different principles in urine, and especially the naked acids which it contains, are also to be carefully observed; as is likewise the phosphate of lime suspended in it; both which vary strangely in diseases of the joints, of the aponeuroses, and of the bones. Of these facts accurately noted, skilful observers may hereafter make a happy use in medicine; deriving from them, new means of knowing the nature of such distempers, of ascertaining their progress, and perhaps of accomplishing their cure.

XIII. We can say little concerning the other animal fluids, such as the humour that is transpired from the pores, sweat, the gastric juice, the cerumen of the ears, the saliva, the humour of tears, the mucus of the nose, the seminal fluid, &c. because all these fluids have hitherto been but little examined. They have, every one, no doubt, a particular composition, different in each of them, from all the rest, in various points, especially in the proportion of their principles. Some of these principles being somewhat better known by modern experiments, than the rest, exhibit a combination of a particular mucilage with water, pure soda, phosphate of lime, and phosphate of soda. Such are tears, the mucus of the nose, and the spermatic juice. Of these, the two former possess the property of becoming thick by the contact of air, and the absorption of oxigene; which probably constitutes the maturity of the humours in the brain and lungs in cases of catarrh. The seminal fluid exhibits the singular phenomenon of the crystallization of phosphate of lime, hitherto unknown in other instances.

XIV. Considering the whole of those solid matters which compose the varied contexture of the different organs of animals; we may divide the substances that form them into three principal genera. The first of these will comprehend the albumen; the second the gluten or gelatinous matter;



the third, the fibrina or fibrous matter. Of these bodies two have already been noticed in the VIII. section of this chapter, under the article, *Blood*. We shall here briefly mention those permanent phenomena which are to be considered as the characters of each of the genera.

#### FIRST GENUS.

*Albumen* is concrescible by heat, by acids, by oxides, and in general by oxigene whenever it is concrete or nearly concrete; is soluble by alkalis; exists, more or less condensed or oxygenated, and wrought into consistency, in the membranes, the tendons, the gristles, and in general, in all white animal matters.

#### SECOND GENUS.

The *gluten*, partakes of the solidity of the former genus in most of the white organs; is susceptible of easy separation and solution by boiling water, to which when cooled, it gives the form of a jelly. As it forms the base, or the larger proportion in all the white organs in general; these are susceptible of more or less perfect solution in boiling water, and form transparent jellies by the refrigeration of their solutions.

#### THIRD GENUS.

The *fibrina* is insoluble in water at any temperature; is soluble in acids; contains a large proportion of azote; is condensed, concremented, and organized in muscular flesh, which may be regarded as the reservoir of all the fibrina contained in the blood. Considering the muscles as the secretory organs of this fibrous matter of the blood; we may examine and observe all the modifications of the quantity or proportion in which it is fixed in those organs; and may attend particularly to that exclusion of it, which they seem to exact in certain morbid states of the body, in old age, &c.

XV. These three matters, albumen, gluten, and fibrina, in concretions, in combinations of two and two, or three and three

three together, especially if they be in different proportions, compose all the solids of animal bodies. They are separated from one another by an easy and simple analysis. They form also various animal fluids, particularly albumen. Only, in these fluids, they contain less oxigene, more water, and are united with acids, neutral salts, &c. It is to be observed, that the gluten is as scanty in the fluids, as it is copious in the solids: and seems therefore to owe its gelatinous nature to that elaboration which it undergoes, when passing from a fluid to a solid state. Albumen artificially dissolved by acids, assumes properties analogous to those of the gluten.

XVI. The solid, osseous substance of animals, is of another order of composition. A large quantity of an almost insoluble terrene salt (phosphate of lime) is deposited in the primitive contexture or parenchyma of the bones. This is the whole mystery of the structure and composition of these organs. In consequence of this, bones afford a jelly by decoction in water, and yield by distillation, a large proportion of oil and ammoniac. Bones once well calcined or burnt, are after this, nothing more than calcareous phosphate, mixed with some portions of carbonate, muriate, and phosphate of soda.

XVII. When these preceding animal matters, especially when the white fluids inspissated, or the white organs, are heated with nitric acid; there is disengaged from them, a quantity, greater or smaller, of gas azote, and of Prussic acid gas, which appears to be nothing else than a combination of azote, hydrogene, and carbone, with a small proportion of oxigene. Of this product, the gluten yields the least; the albumen, more; the fibrina, the most. In proportion as this new combination of the principles of animal matters, takes place by means of the nitric acid; those matters seem to return to their original state of vegetable substances; from which, as has been observed, they differ materially in nothing but in possessing a quantity of azote, in having different proportions of carbone and hydrogene, and in the greater complexity of the number



of the combined materials into which the primary elements are formed in the animal compound. Instead of being ternary compounds, as vegetables are, animal matters are quaternary compounds, or even more complex. Azote is the fourth primary principle of animal matters, which they possess in addition to the hydrogen, carbone, and oxygen of vegetables.

XVIII. Thus the conversion of vegetable matters into animal matters, which consists merely in the fixation or addition of azote; is to be considered as the principal phenomenon of animalization. This alone explains the principal difficulties of that phenomenon: and when the mechanism provided for the addition of this azote shall have become sufficiently known; most of the functions of the animal economy, which contribute to, or depend upon it, will then also be known.

XIX. What is already known concerning this last subject, is limited to the following particulars. It is not so much by the addition of a new quantity, as by the removal of other principles in consequence of which the proportion of the azote originally present, becomes greater, that this phenomenon is accomplished. In respiration, the blood exhales a great quantity of hydrogen and carbone; the last either simply dissolved in gas hydrogen, or else reduced to carbonic acid in the very act of circulation, and in the vascular system, as some modern physiologists have conceived. In the cavities of the *bronchiæ* during the act of respiration, and by means of this act, the hydrogen forms water which is exhaled in expiration. A portion of the oxygen appears to be at the same time fixed in the blood in the lungs; and circulating with this fluid through the vessels, it is gradually combined with the carbone, so as to form that carbonic acid which is disengaged from the venous blood in the breast. It is easily conceived, that a large quantity of hydrogen and carbone being thus disengaged by respiration, the proportion of the azote must be by the same act increased. The investigation of the mechanism of the other functions,

functions, will no doubt lead to new discoveries more important than these which are here detailed. What has been done within these last few years, naturally leads us to expect, that much more may within no long time be done. The analogy of action which has been discovered to subsist between digestion, respiration, the circulation, and transpiration, has begun to establish upon new views much more solid than those which were formerly entertained,—a system of animal physiology that promises a rich harvest of discoveries and utilities. No doubt, by the assiduous investigation of the phenomena of digestion and of growth in young animals, we shall at length succeed so far as to erect upon those bases, a structure equally new and solid. Every thing is ready for this grand series of researches: Several philosophers have already entered upon it: A new ardour springing from the new conceptions which they have formed, stimulates and encourages those who are engaged in this department of physics. The path which they have opened up, cannot fail to conduct them to results the most precise and accurate; exceeding in these qualities, all that has been hitherto advanced concerning the functions which constitute animal life.

*Application of these propositions.*

The functions of the animal œconomy; and particularly,

Respiration;

Digestion;

Hæmatosis, or the formation of blood;

Transpiration;

The secretion of the bile;

Ossification and osteogony;

Nutrition;

Maladies arising from the corruption of the humours, &c.

Animal concretions;



The action of various medicines upon the humours,  
&c.;

Those arts which are employed in the treatment of animal matters; particularly, the arts of the tanner, the currier, the maker of glues, the maker of whipcords; the arts of extracting oils, and of manufacturing into useful implements, the horns, bones, hooves, &c. of animals.

C H A P.

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## CHAP. XII.

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### *Of the SPONTANEOUS DESTRUCTION of ANIMAL and VEGETABLE MATTERS.*

I. WHEN vegetables and animals are deprived of life, or when their products are abstracted from the individuals to which they belonged; movements are then excited in them, which destroy their contexture, and alter their composition. These movements form different sorts of fermentations. The purpose of Nature in exciting them, is evidently to render more simple, those compounds which are formed by vegetation and animalization; so that they may enter readily into new combinations of different kinds. That matter which has been for a time employed in forming the bodies of vegetables and animals, is, after their functions are ended, to pass through other combinations, and to enter into the composition of other bodies.

II. From this definition of fermentation in general, it appears, that the species of fermentation must be as various as those of the animal and vegetable substances that are affected by it. But, of these, a number pass through the same process, while they are reduced to greater simplicity of composition; and in reference to this, all the variety of fermentations may be reduced



to three leading species; vinous fermentation, acetous fermentation, putrid fermentation.

III. Vinous fermentation, as its name indicates, is that fermentation which produces wine or alcohol. The only matter subject to it, is saccharine matter, diluted in a certain quantity of water, and mixed with some third matter, vegetable or animal, extract, salt, feculum, &c.; for it is now certain, that sugar and water alone are not susceptible of vinous fermentation. The saccharine substance is so copious, and so universally diffused through all vegetable and even animal matters; that there is a prodigious number of bodies capable of affording wine or forming alcohol. All sweet and saccharine fruits when reduced to a pulp, and particularly their expressed juices, undergo an internal motion at a temperature not under  $66^{\circ}$  F. if they be at the same time, in a large quantity, and neither too thick, nor too liquid. Hence that vast quantity of different wines which we possess; reckoning with them, the decoctions of germinating grains, in which the saccharine part is developed by germination; and even the vinous liquors made with milk, honey, blood, &c.

IV. Vinous fermentation discovers itself in saccharine juices, by an increase of their bulk, the formation of a copious froth that covers their surface, rise of temperature, the disengagement of a great deal of carbonic acid, the conversion of a sweet liquor into an acid, hot, and pungent fluid.

V. The cause of this fermentation appears to depend on the decomposition of water, of whose oxigene, a large share is brought into union with the carbone of the sugar, which it burns, and so converts it into carbonic acid. At the same time, the hydrogen of the water, is brought into contact with the decarbonated sugar, and by combination with it, forms alcohol. Alcohol may be defined to be *sugar, deprived of a portion of its carbone, the place of which is supplied by a certain proportion of hydrogen*. This theory explains both the formation of the carbonic acid which is disengaged during

vinous

vinous fermentation; and the formation of alcohol, with all the properties of this new product.

VI. Pure alcohol is a white liquid, of a strong smell, of an hot and acrid taste, convertible into vapour at the temperature of  $176^{\circ}$  F. inflammable at any temperature; affords, when burning, a large proportion of water and carbonic acid; diffuses no smoke during its combustion; is miscible in any proportion with water, expelling the air and a portion of caloric, while the combination takes place; dissolves the pure or caustic alkalis; decomposes the acids, and by this decomposition, is itself converted into æther; dissolves deliquescent neutral salts, and many metallic salts; detaches from vegetables their volatile oil, aroma, resin, balsam, a part of their gum-resin, and several colouring matters; is by means of all its properties, useful in many operations of the arts.

VII. The formation of alcohol is effected by the destruction of a principle of vegetables; the saccharine matter suffering upon this occasion, a decomposition by which it is reduced to greater simplicity. Vinous or alcoholic fermentation is therefore a commencement of the destruction of those principles which are formed by vegetation. It may be considered as an interior emotion, designed by Nature, to simplify the order of composition which vegetable substances exhibit.

VIII. Acid or acetous fermentation is the second natural movement by which vegetable compounds are reduced to a more simple state of composition. This fermentation which produces vinegar, can take place only in liquors that have already undergone vinous fermentation. It has been remarked that the contact of air is necessary for the production of vinegar. We have even seen air to be absorbed by wine turning sour; and it appears, that a certain proportion of oxigene from the atmosphere is necessary to the formation of acetous acid.

IX. There, are no doubt, other sorts of fermentation analogous to that by which vinegar is formed; but of such fermentations the products are not yet well known. Such, for instance,



stance, is that which takes place in water mixed with starch, which is called the starch-maker's four water. Such likewise is that of soured bread, soured cabbages, and four liquors. All these changes are to be considered as modes of decomposition which serve to simplify the complicated combinations of vegetables.

X. Lastly, After that the liquids of vegetables, or their solids moistened, have passed into the acid state; their decomposition continuing under favourable circumstances; that is to say, in a mild or hot temperature, exposed to the air, or in contact with water; conducts them to a putrefaction by which they are in the end volatilized, in the form of gas, as to most of their principles. There is disengaged, water, carbonic acid, carbonated gas hydrogen, sulphurated gas hydrogen, volatile oil in vapour, and sometimes, even gas azote, and ammoniac. Nothing remains, after this, but a brown or black residue, known by the name of *mould*, consisting of carbone that is somewhat fat and oily, and from which water extracts several saline substances, and a small portion of extractive matter.

XI. Nature, when organizing animals, and forming their humours and solids by complex compositions; has mingled in their composition a germ of destruction, which unfolds itself after the death of the individual.

This destruction is effected by that movement which is called *putrefaction*. It consists in a sort of fermentation, in a slow decomposition of those liquid or solid substances in which it takes place. The order of the composition of animal matters is more complex than that of vegetables, and renders them much more susceptible of putrid decomposition.

XII. Animal matters being compounded of hydrogen, carbone, oxigene, and azote; and having often superadded to these principles, portions of sulphur, phosphorus, &c.; when they are deprived of that motion and continual renovation which constitute animal life; are soon altered by the more simple mutual attractions of their principles, which tend to combine together,

together, by two and two. This re-action produces binary compounds, such as carbonic acid, nitric acid, ammoniac, carbonated gas hydrogene; which are by degrees evolved into the atmosphere; and as they are evolved, proportionally diminish the bulk of the animal matters from which they are separated. It is in this manner, and in consequence of natural decomposition; that animal matters are seen to become soft, to change their colour and smell, to lose their structure and form, to diffuse through the atmosphere, vapours and gasses which are there dissolved, and are destined to convey into other bodies, particularly into vegetables, the materials necessary to their formation.

XIII. All the phenomena of the putrefaction of animal matters, depend upon the mechanism which has been explained. The union of hydrogene and azote produces ammoniac, which has been regarded as the principal product of putrefaction. The combination of carbone with oxigene accounts for the formation and disengagement of carbonic acid, in which all the mysteries of putrefaction were supposed to consist, about the time of the first discovery of the gasses. The nitric acid, to the formation of which, animal matters powerfully contribute in artificial nitre-works,—is produced by the union of azote with oxigene. A certain quantity of gas hydrogene is disengaged, and involves with it some portions of carbone, sulphur, and even phosphorus. Hence that noisome smell, which is so exceedingly various, and hence, perhaps, the phosphorescence of all putrefying animal substances.

XIV. When all these volatile principles are combined two and two together, and dispersed through the atmosphere, there remains no residue, but a portion of carbone, united or mixed with fixed saline substances, such as phosphate of soda, and phosphate of lime. These residues form a sort of *mould* that is called *animal earth*; which often retains in it a little sulphurated and carbonated hydrogenous gas, a little fat, and some extract; and in which vegetables find abundance of those

principles



principles which are fit for the formation of their materials. Hence is it that this animal residue, when the previous putrefaction is entirely past, forms an excellent species of manure.

XV. There is a certain quantity of water necessary to this putrid decomposition of animal matters. It affords the oxygen requisite to the composition of the carbonic acid and nitric acid. It contributes remarkably to excite the putrefactive emotions, by means of the attractions of its oxygen. The hydrogen, too, evolved from the water, must doubtless contribute greatly to the formation of the ammoniac: for it is a well known fact, that, when animal matters are diluted in a large quantity of water, they afford abundance of ammoniac, during their decomposition.

XVI. Putrefaction, consisting in a series of peculiar attractions, is modified in many different ways by all its exterior circumstances, such as temperature, the medium in which animal matters are placed, the state of the atmosphere, as more or less ponderous, dry or humid, &c. It is thus that carcases buried in the earth, immersed in water, or suspended in air, undergo a diversity of changes to which their mass, their quantity, and the vicinity of other bodies, as well as all the varied properties of the three media here mentioned, continually give new and different forms.

XVII. Proofs of the truth of this assertion, occur in what happens to dead bodies, interred either separately, each by itself,—or in heaps together. The former being surrounded by a great quantity of earth, are soon destroyed by putrefaction, the æriform or liquid products of which are absorbed by the surrounding earth, or by the atmosphere. Bodies buried in heaps together, not having around them the same sort of earthen or atmospheric receiver, remain long undestroyed; their animal matter is entirely converted into ammoniac and concrete oil: and this oil with the volatile alkali, forms that saponaceous matter which has been found in the earth of burying grounds, in which there has been too great a number of corpses deposited.

XVIII.

XVIII. In water, different phænomena attend the destruction of animal matters: As fast as the new products are formed, the water dissolves, and conveys them into the air. A continued moisture at a temperature, a few degrees above  $32^{\circ}$  F. favours the putrefaction of these matters, and their solution into gas. A dry, hot air, on the contrary, volatilizing the water, dries and hardens the animal bodies, almost as well as the dry burning sand does in Egypt, that land of mummies.

XIX. Although all the circumstances of putrefaction, and all the varieties, almost innumerable, of the phænomena which they exhibit; have not been as yet either discovered or described; it is however acknowledged, that all those phænomena must be limited to the conversion of the more complex compounds into others of a simpler composition; which Nature then employs in new combinations forming the materials of other complex bodies. She had only lent them for a time to animals and vegetables. She carries on a perpetual circulation of compositions and decompositions; which display her power, and evince her fecundity, at the same time while they shew a plan of action, equally grand and simple in its operations.

*Application of the propositions in this last chapter.*

Beside all the objects mentioned at the end of the two chapters immediately foregoing, to which the articles in this chapter afford almost direct applications; the principles particularly explained in this chapter, are likewise susceptible of these following applications.

The preservation of all substances extracted from vegetables;

The different spontaneous alterations which vegetables undergo; acetous fermentation, vinous fermentation, &c.;

The



The products of these alterations, often employed in the arts ;

The production of ammoniac and nitric acid ;

The influence of putrefaction in the different regions of living bodies ;

The infection, and other evils, produced by the vapours of putrefied matters ;

The theory of the situation and management of hospitals, drains, sinks, lay-stalls, common-sewers, cemetaries, &c.